Archives of Neurology and Psychiatry

VOLUME 57 MARCH 1947 NUMBER 3

COPYRIGHT, 1947, BY THE AMERICAN MEDICAL ASSOCIATION

HEADACHE

The Teeth as a Source of Headache and Other Pain

SCHUYLER ROBERTSON, M.D.

HELEN GOODELL, B.S.
AND
HAROLD G. WOLFF, M.D.
NEW YORK

AFFERENT impulses from the teeth are carried by branches of the second and third divisions of the fifth cranial nerve. Through the apex of the tooth, nerves enter the pulp accompanying the larger vessels and form an almost complete mantle around the arteries.[1] Vascular walls in the tooth pulp are innervated by unmyelinated fibers. Nerve fibers from the tooth pulp form a complicated network between the odontoblasts and then pass into the partially calcified layer of the dentine, and sometimes into the inner margin of the calcified dentine itself[2] (fig. 1).

Brashear[3] found that the pulp nerves in human teeth contain more than 50 per cent of unmyelinated and small myelinated nerve fibers less than 6 microns in diameter. The rest vary in size up to 10 microns. No pulp fibers were found to be more than 10 microns in diameter. He observed that thermal, mechanical or chemical stimulation of the dentine of a normal human tooth results in pain, and in no other sensation. Pfaffman[4] observed that "painful" stimulation of the teeth gives rise only to slowly conducted potentials, presumably related to fibers of smaller diameter. On the other hand, there are nerve fibers of all sizes present in the periodontal tissues, and it is likely that other sensations, such as touch and pressure, in addition to pain, originate in these tissues.[3]

In the following study an attempt was made to ascertain the distribution and mechanism of headache and other pain in the face and head

From the New York Hospital and the Departments of Medicine and Psychiatry, Cornell University Medical College.

1. Berkelbach van der Sprenkel, H.: Microscopical Investigation of the Tooth and Its Surroundings, J. Anat. **70**:233, 1936.

2. Lewinsky, W., and Stewart, D.: The Innervation of the Dentine, J. Anat. **70**:349, 1936. Tiegs, O. W.: Further Remarks on the Termination of Nerves in Human Teeth, ibid. **72**:234, 1938.

3. Brashear, A. D.: Innervation of the Teeth, J. Am. Dent. A. **23**:662, 1936.

4. Pfaffman, C.: Afferent Impulses from the Teeth Due to Pressure and Noxious Stimulation, J. Physiol. **97**:207, 1939.

resulting from noxious impulses originating in the teeth. The effects of noxious impulses experimentally induced and of those arising from morbid processes were studied.

METHOD

Two different electrical methods were employed for inducing pain experimentally in the teeth: the one for inducing toothache well above the pain threshold,[5] and the other for inducing pain only at the pain threshold.[6] For inducing toothache of high intensity, the Hinsey-Geohegan stimulator was used.[5] It employed a 60 cycle alternating current, of 110 volts, with a step-down transformer giving a voltage from 0 to 25. The bipolar electrode was insulated to the tips. The handle of the electrode was held by the subject, and its tips were placed securely against a tooth. It was found that the best sites for inducing pain in a tooth were small "pit" caries and traumatic chips in the enamel. Toothaches were induced in 6 subjects, but most of the observations were made on subjects R and G. These 2 subjects discovered defects and enamel chips in

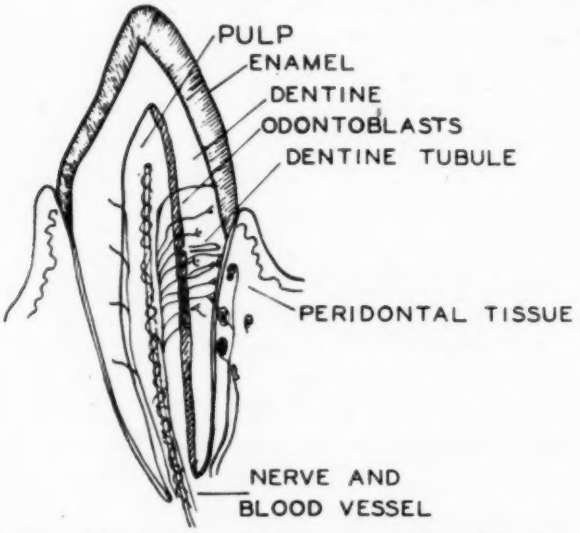


Fig. 1.—Diagram indicating the structure of a tooth and its innervation. Only pain afferent fibers occur within the tooth. Periodontal tissue contains afferent nerves for other sensory modalities.

their teeth which they allowed to remain in an unrepaired state during the period of experimentation.

Pain was estimated on an arbitrary basis of 1 to 10 plus, 10 plus being pain of extremely high intensity, or the "worst" pain the subject had ever experienced. With the subject sitting in a chair and the electrode held firmly in place, the rheostat was gradually advanced from 0 to a voltage sufficient to induce a toothache of 4 to 8 plus intensity. It was the aim to hold the toothache at this intensity for a period of ten minutes. It was observed that there was a predictability in the intensity of the experimentally induced pain arbitrarily called 4 to 8 plus and that variations in intensity of approximately 1 plus could be estimated

5. Hinsey, J. C., and Geohegan, W. A.: Unpublished data.

6. Ziskin, D. E., and Wald, A.: Observations on Electrical Pulp Testing, J. Dent. Research **17**:79, 1938.

and remembered from day to day. This method of estimating intensity of sensation has been used in the study of "cold pain" and other types of pain.[7]

During preliminary observations it was learned that an amount of current which initially induced toothache soon ceased to induce pain when it was steadily applied. To obviate this, the voltage was gradually increased and the current momentarily interrupted every five to ten seconds. The intensity of the toothache was thus kept continually at approximately 4 to 8 plus.

The second method was used to induce pain at approximately its threshold by stimulating the tooth with a high frequency current by means of a radio frequency "vitalometer" fashioned according to the method of pulp testing devised by Ziskin and Wald.[6] The instrument applies a potential to the surface of the tooth. Voltage is adjusted through a primary and secondary coupling, and transient peaks of current are generated with frequencies as high as 50,000 cycles per second. A single electrode is applied to the tooth, and the circuit is completed through a coupling held in the subject's hand. With such high frequencies a sensation of burning pain is elicited. The pain threshold is expressed as the smallest voltage which will just elicit this painful sensation.

GENERAL OBSERVATIONS: DESCRIPTION OF THE HEADACHE RESULTING FROM NOXIOUS STIMULATION OF THE TEETH

The headache occurring after experimentally induced toothache is illustrated in the following representative protocols.

SERIES 1.—*Noxious Stimulation of Teeth in the Upper Jaw.*—The points of the stimulating electrode were placed in a defect in the enamel of a premolar or first molar tooth in the upper jaw. Stimulation was begun with 0.5 volt of a current of 60 cycles per second. Pain of 4 to 8 plus intensity experienced locally in the tooth was induced with approximately 1 volt. In order to maintain the toothache at this intensity for a period of ten minutes, the current was broken momentarily at five to ten second intervals, and the voltage was increased gradually to 10 volts. Pain was experienced for the most part locally in the tooth. Occasionally, however, following a momentary break in the stimulating current, the subject experienced a "jab" of more intense pain, described as a "narrow column of pain which spread vertically into the eye, the orbital ridge, and the temple." With extremely intense toothache, pain occasionally spread into adjacent teeth and along the maxilla.

---

7. (*a*) Wolf, S., and Hardy, J. D.: Studies on Pain: Observations on Pain Due to Local Cooling and on Factors Involved in the "Cold Pressor" Effect, J. Clin. Investigation **20**:521, 1941. (*b*) Hardy, J. D.; Goodell, H., and Wolff, H. G.: Studies on Pain: Observations on the Hyperalgesia Associated with Referred Pain, Am. J. Physiol. **133**: P 316, 1941. (*c*) Wolff, H. G.: Some Observations on Pain, in The Harvey Lectures, 1943-1944, Baltimore, Williams & Wilkins Company, 1944, vol. 39, p. 39. (*d*) Hardy, J. D.; Wolff, H. G., and Goodell, H.: Studies on Pain: A New Method for Measuring Pain Threshold; Observations on Spatial Summation of Pain, J. Clin. Investigation **19**:649, 1940. (*e*) Hardy, J. D.; Goodell, H., and Wolff, H. G.: Studies on Pain: The Ability to Discriminate Intensities of Pain, to be published.

The period of toothache was accompanied with intense apprehension, profuse salivation, lacrimation, flushing of the face on the side of the stimulation and generalized sweating. When the stimulation of the tooth was terminated, the intense pain in the tooth decreased quickly to a pain of less than 1 plus intensity, lasting approximately two minutes. This pain was then replaced by a feeling of pressure in and around the tooth, which was described as "the sensation of a foreign body lodged between the teeth." Within a few seconds after the termination of the toothache there began a sensation of tightness about the tooth, slight numbness and a sense of fulness over the cheek, and a tight, stiff sensation in the skin and deep tissues in the temporal region, the forehead and the scalp on the same side of the head. There was stiffness on motion of the jaw, and occasionally a sense of fulness in the ear. Within five to ten minutes after all pain in the tooth was terminated, a

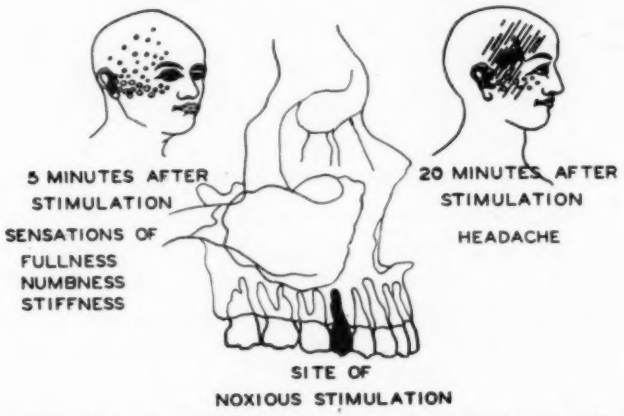


Fig. 2.—Distribution of sensations of fulness, numbness and stiffness and distribution of headache following noxious stimulation of a tooth on the right side of the upper jaw.

steady aching, diffuse pain of 1 plus intensity was experienced in the homolateral temporal region, along the zygomatic ridge and for a short distance over the eye (fig. 2). There was no throbbing component to the pain. Bending over and looking into a bright light increased its intensity. It could usually be eliminated by administration of 0.3 Gm. of acetylsalicylic acid.

The headache reached its maximum distribution and intensity of 2 plus within twenty to thirty minutes after termination of the noxious stimulation and cessation of the toothache (fig. 4). The sensations of tightness, fulness and numbness were comparatively short lived, whereas the headache persisted for from one to eight hours, and in 1 instance for twenty-four hours, gradually diminishing in intensity. During the period of most intense headache, there were photophobia and injection of the conjunctiva. In addition, the temporal muscle and overlying

tissues on the same side as the pain were tender to palpation, and skin over the painful area was hyperalgesic; i. e., pinprick was sharper and persisted longer than in other areas. Associated with the hyperalgesia was a pilomotor reaction, manifested by cutis anserina on the face and arm on the same side. The pain threshold of the hyperalgesic skin as tested by the Hardy-Wolff-Goodell apparatus was not lowered.[8]

SERIES 2.—*Noxious Stimulation of Teeth in Lower Jaw.*—A lower premolar or first molar tooth was stimulated in the manner previously described, maintaining a toothache of 4 to 8 plus intensity for a period of ten minutes. Throughout the period of stimulation intense aching pain was experienced locally in the tooth, and there was a less intense aching pain throughout the lower jaw, which usually extended into the anterior wall of the auditory canal. At the end of the period of stimu-

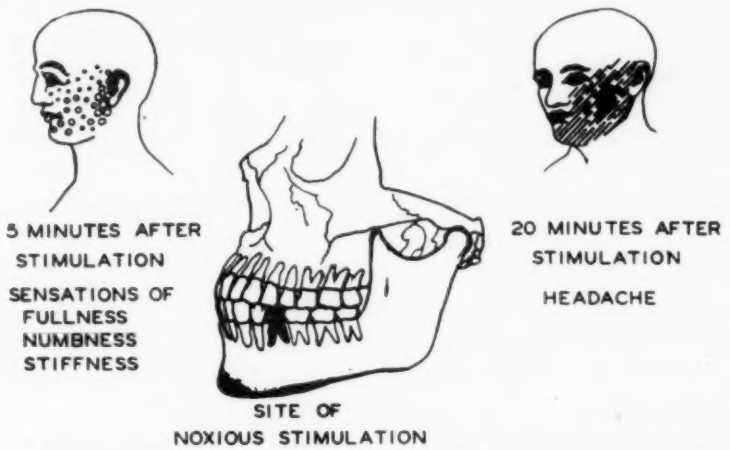


Fig. 3.—Distribution of sensations of fulness, numbness and stiffness and distribution of headache following noxious stimulation of a tooth in the left side of the lower jaw.

lation the pain of high intensity was quickly terminated, but there persisted a sensation of pressure in the tooth. Sometimes, together with the pressure, there was a dull, diffuse, aching pain of low intensity throughout the lower jaw on the side stimulated. During the ten to fifteen minutes following the end of the period of electrical stimulation there developed first a sensation of fulness and heaviness and then, in addition, pain of 2 to 3 plus intensity, which extended throughout the upper and the lower jaw into the area over the zygoma and the temple to the top of the ear. There was also a sensation of fulness and aching in the ear. This primarily "lower half" headache was increased in intensity by biting and by bending over. It persisted for periods of one to eight hours.

8. Footnote 7 *a*, *b*, *c* and *d*.

The effects of noxious stimulation of teeth in the upper and lower jaws were similar (see figure 3 for distribution of pain) with regard to the accompanying apprehension, lacrimation, salivation, flushing of the face, photophobia and generalized sweating, as well as stiffness of the masseter muscle and the quality of the pain and its response to acetylsalicylic acid.

Toothaches were induced by the method of electrical stimulation described in series 1 and 2 in thirty-two experiments on subjects R and G and in one experiment each on subjects S, W, V and B. Headache did not follow the toothache unless the latter was maintained at 4 to 8 plus intensity for a period of eight to ten minutes. The effects of the noxious stimulation were completely reversible, since no sequelae were noted.

Comment.—A review of the observations on pain in thirty-two experiments in which noxious stimulation of a tooth in the upper or the lower jaw was maintained for ten minutes justifies the following general comment.

Noxious impulses arising from one or more of the upper teeth resulted in pain which was experienced at first locally, and then diffusely, in tissues supplied by the second division of the fifth cranial nerve. Noxious impulses arising from one or more of the lower teeth also caused pain to be experienced at first locally and then widely in the tissues supplied by the third division of the fifth cranial nerve. Often, moreover, the site at which pain was felt was remote from the primary source of noxious impulses. If the noxious stimulation of the teeth was sufficiently intense and prolonged, regardless of the site of origin, the pain usually spread and was experienced also in tissues supplied by the first as well as by the second and third divisions of the fifth cranial nerve. The size of the painful area bore no close relation to the size or localization of the noxious stimulation but prolonged disturbances were more likely to give rise to distant pain than were short-lived stimulations.

Furthermore, homolateral hyperalgesia, tenderness and vasomotor reactions of tissues remote from the source of noxious impulses in the teeth, such as tenderness of the eyeball, reddening of the conjunctiva and tenderness of the temporal and auricular tissues, were common.

STUDIES ON PAIN THRESHOLD OF THE TEETH

Ivy and associates,[9] using electrical stimulation of the teeth, found that the pain threshold of a tooth is predictable if the stimulating electrode is always placed on the same site. These workers used a filling

9. (*a*) Goetzl, F. R.; Burrill, D. Y., and Ivy, A. C.: A Critical Analysis of Algesimetric Methods with Suggestions for a Useful Procedure, Quart. Bull., Northwestern Univ. M. School **17**:280, 1943. (*b*) Burrill, D. Y.; Goetzl, F. R., and Ivy, A. C.: The Pain Threshold Raising Effects of Amphetamine, J. Dent. Research **23**:337, 1944.

in a tooth as a site of stimulation and were able to demonstrate a consistent elevation of the pain threshold after the administration of certain analgesics. The modification of the method of Ziskin and Wald,[6] previously described, was utilized in this study for ascertaining the

TABLE 1.—*Intensity of Stimuli Eliciting Pain by Stimulation of Teeth with a Nerve Stimulator (Hinsey-Geohegan), Using 60 Cycle Alternating Current* *

Tooth		Right		Left	
		Stimulus, Volts	Effect	Stimulus, Volts	Effect
		Subject H. G.			
Central incisor	(1)	25	No pain	25	Threshold pain
Lateral incisor	(2)	25	No pain	25	No pain
Canine	(3)	25	No pain	3.5	Pain
First premolar	(4)	19	Pain	25	No pain
Second premolar	(5)	0.5	Pain	25	No pain
First molar	(6)	15	Pain	21.5	Pain
Second molar	(7)	2	Pain	23	Pain
		Subject S. R.			
Central incisor	(1)	9.5	Pain	25	No pain
Lateral incisor	(2)	8	Pain	0.5	Threshold pain
Canine	(3)	9	Pain	0.5	Threshold pain
First premolar	(4)	13	Pain	19.5	Pain
Second premolar	(5)	2	Pain (threshold)	13.5	Pain
First molar	(6)	16.5	Pain (threshold)	7	Pain
Second molar	(7)	4.5	Pain	13	Pain

* The apparent variability of the pain threshold in teeth as measured by this technic is demonstrated.

TABLE 2.—*Intensity of Stimulus Eliciting Pain by Stimulating Teeth with a High Frequency "Vitalometer"* *

Subject	Tooth †	Thresholds	
		Stimulus in Volts at Various Sites	Stimulus in Volts at Same Site
R	L 3	6.8, 8.0, 5.4	
	R 3	4.0, 6.5, 5.4, 3.8, 5.3, 5.9	
B	L 3	6.0, 4.2, 4.8	4.4, 4.2, 4.2
R	L 4	5.3, 6.3, 7.5, 10.5, 8.2, 5.5, 14.0, 5.8	
	R 4	5.7, 3.9, 6.0	
B	L 4	.....	3.8, 4.0, 3.6, 4.0
G	L 4	10.5, 7.5, 6.0, 4.5, 9.8	
R	L 5	9.8, 6.1, 5.5	5.3, 5.8, 5.5
	R 5	7.6, 5.3, 5.5	5.3, 5.5, 5.1
G	L 5	3.0, 4.0, 5.0, 5.5	5.0, 5.5, 5.0
G	L 6	4.0, 7.5, 1.5, 6.5	

* The variability of the pain threshold at various sites in the same tooth and the relative uniformity of the pain threshold at the same site on repeated trials are demonstrated.
† L 3, L 4, L 5 and L 6 indicate the canine, first premolar, second premolar and first molar on the left side of the upper jaw; similarly, R 3, R 4 and R 5 indicate corresponding teeth on the right side.

pain threshold of teeth. The effects of noxious stimulation of a tooth on its pain threshold were also studied.

Observations.—In subjects R, G and B it was observed that there was a considerable variation in the pain threshold from tooth to tooth and at various sites on a single tooth, depending on the thickness and intactness of the enamel at the site of application of the stimulating electrode (tables 1 and 2). There was also no uniformity of the pain threshold from tooth to tooth in the same subject or in corresponding teeth from

one person to another. However, the pain threshold of a single tooth, when the tip of the electrode was placed on the same spot, was uniform within a range of + 6 per cent.[10] If the electrode was moved on the tooth, variations in the pain threshold as great as 300 per cent were sometimes observed.

EFFECT OF NOXIOUS STIMULATION ON PAIN THRESHOLD OF THE TEETH AND RELATION OF INTENSITY OF HEADACHE TO LOWERING OF THRESHOLD

A series of observations on the pain threshold were made on three adjacent teeth in subjects R, G, B and W. The upper premolar and first two molar teeth were used. After four to six consistent threshold measurements on each tooth, the middle one of the three teeth, the first molar, was painfully stimulated for a period of ten minutes, and the toothache was maintained at 4 to 8 plus intensity, as previously described. The pain thresholds of the three teeth were again ascertained after cessation of the painful stimulation and at ten and fifteen minute intervals during the next hour.

Results.—During the period of twenty to thirty minutes after stimulation of the tooth, when the intensity of the headache in the temporal area was at its maximum, the pain threshold of the stimulated tooth, now no longer aching itself, was lowered 35 per cent below its control level (fig. 4). The pain thresholds of the adjacent, "control" teeth were not altered. The "experimental" tooth was also "painful" when cold air was sucked through the mouth or when the subject drank cold water. Two such experiments were performed on subject R, two on subject G, one on subject B and one on subject W.

Comment.—"Hyperalgesia," i. e., overreaction to pinprick, in sites remote from the zone of noxious stimulation is not associated with a lowered pain threshold.[11] By contrast, in the zone of noxious stimulation, the pain threshold is appreciably lowered. The aforedescribed lowering of the pain threshold of a tooth following noxious stimulation is in accord with the observations of Lewis and Hess [12] and of Schumacher [13] on the skin. It has also been demonstrated that an agent was present in the blister fluid of skin injured by heat which was capable of lowering the pain threshold in a healthy site in which the fluid was injected.[14]

---

10. Schumacher, G. A.; Goodell, H.; Hardy, J. D., and Wolff, H. G.: Uniformity of the Pain Threshold in Man, Science **92**:110, 1940.

11. Hardy and associates.[7b] Hardy.[7e]

12. Lewis, T., and Hess, W.: Pain Derived from the Skin and the Mechanism of Its Production, Clin. Sc. **1**:39, 1934.

13. Schumacher, G. A.: The Influence of Inflammation on the Pain Threshold of the Skin in Man, A. Research Nerv. & Ment. Dis., Proc. (1942) **23**:166, 1943.

14. Bigelow, N., and Goodell, H.: Unpublished observations.

These observations on lowering of the pain threshold in the teeth are also in keeping with the common experience that ordinarily non-noxious stimuli, such as cold or hot water in the mouth, can induce pain in a tooth when it is diseased. Edema, dilatation of blood vessels and cardiac systole, when there are inflammation and lowered pain threshold, also become adequate stimuli and give toothache its characteristic throbbing quality. Furthermore, it was found during high altitude flying that a diseased tooth which did not give rise to pain on the ground became painful with a drop in the barometric pressure. The authors observed that the sooner the pain starts during ascent, the more acute the inflammation in the tooth is likely to be, indicating a low pain threshold in the affected tooth.[15]

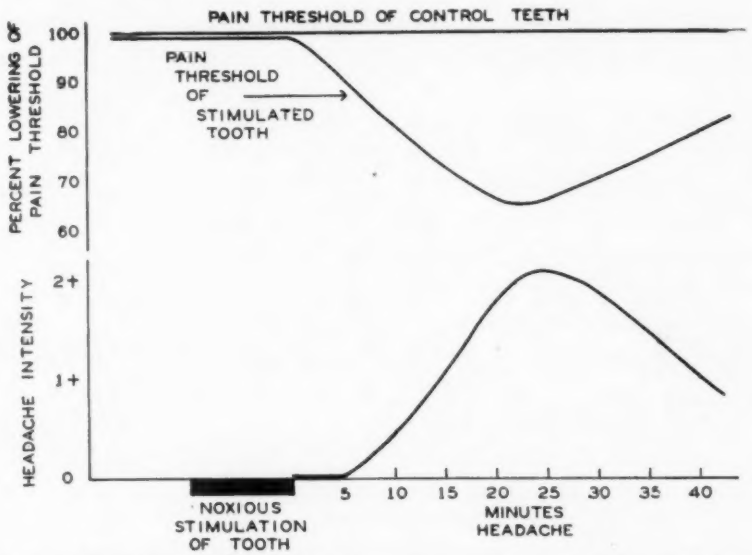


Fig. 4.—Lowering of pain threshold as measured by a "vitalometer" in a tooth which had been noxiously stimulated. The lowering of the pain threshold in the tooth was accompanied with headache on the homolateral side. The pain thresholds of the two adjacent teeth were not altered.

In short, in a tooth with a lowered pain threshold, ordinarily inadequate stimuli become noxious stimuli and give rise to pain. It is postulated that the experimental noxious stimulation of the tooth results in a local inflammatory reaction within the tooth, which outlasts the period of experimental stimulation, and perhaps also in the local liberation of a substance which lowers pain threshold. Because of the lowered pain threshold, minor tissue changes, such as vasodilatation and edema, become capable of evoking impulses which incite central spread of exci-

15. Orban, B., and Richey, B. T.: Toothache Under Conditions Simulating High Altitude Flight, J. Am. Dent. A. **32**:145, 1945.

tatory effects. These are ultimately experienced as headache remote from the site of stimulation.[7e]

ANALYSIS OF THE HEADACHE AND OTHER PAIN FROM BRIEF EXPERIMENTAL NOXIOUS STIMULATION OF THE TEETH

A. Effect of Injections of Procaine Hydrochloride into the Tissues in the Zone of Headache.—In three experiments on 2 subjects, R and G, 1 cc. of a 1 per cent solution of procaine hydrochloride was infiltrated intracutaneously into the site of most intense temporal headache. Within a few seconds after the injection there was analgesia of the skin in an area of approximately 4 to 6 sq. cm., and the subjects estimated that a considerable portion of headache was eliminated. The temporal muscle beneath the analgesic skin remained tender to palpation. Pain, however, continued to be experienced over the eye and in the scalp above the analgesic area; and a less intense, diffuse ache seemed

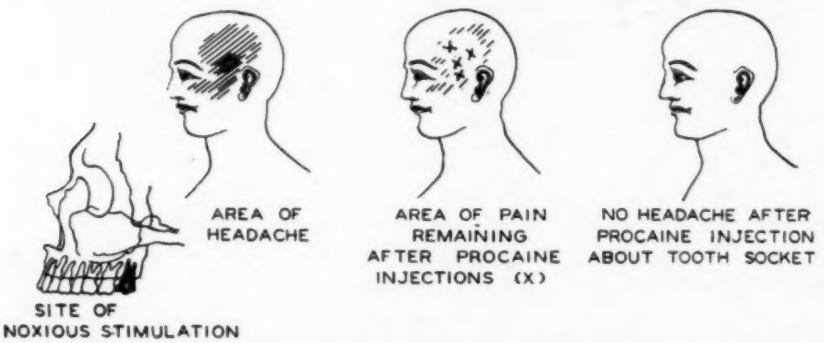

AREA OF HEADACHE
SITE OF NOXIOUS STIMULATION
AREA OF PAIN REMAINING AFTER PROCAINE INJECTIONS (X)
NO HEADACHE AFTER PROCAINE INJECTION ABOUT TOOTH SOCKET

Fig. 5.—Area of headache following noxious stimulation of a tooth and the effect of injections of procaine into the painful area, as compared with the effect of injection of monocaine into the site of noxious impulses.

to emanate from the temporal muscle underlying the analgesic area. Pain also continued to be experienced along the zygoma and over the outer corner of the eye after the intracutaneous injection of procaine into the temporal area. In subject G, the sensations of fulness and tightness in the upper jaw and of fulness in the ear also continued after elimination of pain in the temporal area. When the procaine was injected intramuscularly, as well as intracutaneously in the temporal region, both subjects experienced a diminution of pain, which again was only partial, as already described and as indicated in figure 5. As the analgesia gradually diminished, the pain returned to its earlier intensity and persisted until it spontaneously subsided or until it was eliminated by administration of acetylsalicylic acid.

B. Effect of Injection of Monocaine Hydrochloride into the Source of Noxious Stimuli (Afferent Nerve or Tissue About the Tooth).—Local infiltration of the skin and muscle in the area of headache where

pain was most intense failed to eliminate pain and the sensations of fulness and tightness in areas adjacent to the area of analgesia. It was therefore ascertained to what extent these remaining sensations were due to noxious impulses originating in the tooth so recently the site of noxious stimulation and toothache. Therefore, in each of the subjects G and R at approximately twenty minutes after the period of noxious stimulation, when the subsequent headache had developed its maximum intensity of 2 to 3 plus, and was of maximum distribution, as previously described, the tissues around the base of the noxiously stimulated tooth were infiltrated with 1 cc. of a 1 per cent solution of monocaine hydrochloride.[16] Immediately with the development of paresthesia in the gums, and even before the development of analgesia, there was complete elimination of all pain and sensations of fulness and tightness in the head remote from the site of noxious stimulation. In subject G headache returned with the return of sensation in the gums, but subject R remained free of pain.

Experiment: On August 30, for therapeutic reasons, subject R had his third left upper molar tooth extracted at 11:50 a. m. The tissues around the tooth were infiltrated with monocaine hydrochloride before the extraction, and the latter was quickly performed, without pain. One hour and twenty minutes after the extraction, however, the analgesic effect of the monocaine was ended, and he experienced a 1 plus intensity of pain and tenderness in the tooth socket. Ten minutes later there developed a headache similar in every respect to that following the experimentally induced toothache. However, it was of greater intensity and extended over a greater area over the forehead and up to the vertex, beyond its zone of maximum intensity in the temporal area (fig. 5). There were lacrimation and slight reddening of the conjunctiva on the left and erythema of the left side of the face, which extended below the jaw into the neck. The skin over the painful area, especially in the temporal area, was hyperalgesic, and pinprick in this area was accompanied with an extensive pilomotor reaction, as evidenced by cutis anserina over the left side of the neck and the left shoulder and arm.

At 1:50 p. m. the intensity of the headache was 3 plus, and there was pain of 1 plus intensity in the tooth socket. One cubic centimeter of procaine hydrochloride (1 per cent) was injected intracutaneously into the temporal region at the site of maximum intensity of pain and over the area of deep tenderness. The patient reported that the "center" of his headache was eliminated, leaving a fringe of headache of 2 plus intensity (fig. 5) and a deep diffuse ache beneath the area of surface analgesia. The pain in the tooth socket remained unchanged.

16. All the injections for periodontal infiltration in these experiments were performed by Dr. Stanley J. Behrman, of the New York Hospital Department of Dentistry.

Again, at 2:20 p. m., procaine was injected intracutaneously into two additional areas, and at 2:30 p. m., since deep ache still remained, two intramuscular injections were made fanwise into the temporal muscle, as indicated in figure 5. The subject continued to experience pain of 2 plus intensity at the periphery of the analgesic area, but he also described a diffuse ache of 1 plus intensity, which seemed to stem from the analgesic area.

At 4:00 o'clock the effects of the injected procaine had diminished, and the headache was again of 3 plus intensity. The subject reported, "This is the same headache I had following experimentally induced toothache, except that it is more persistent and of slightly greater intensity. The tooth socket is painful." At 4:10 o'clock the left middle superior alveolar nerve was blocked with monocaine hydrochloride. All the headache, including the sensations of fulness and tightness was eliminated at once, and the subject experienced no discomfort until about three hours later, when the action of the analgesic was dissipated.

Comment: The speed of elimination of the headache after blocking of the path of afferent impulses from the injured periodontal tissues of the tooth socket makes it likely that the diffuse headache experienced was caused by the noxious impulses arising from these injured tissues. These noxious impulses gave rise to excitatory processes in the brain stem which spread to exert their effects on many trigeminal structures.

C. Electromyographic Observations During Headache.—Preceding and during the headache which followed experimentally induced toothache there were sensations of fulness and tightness in the temporal region, which sometimes extended to the vertex, and tenderness of the temporal muscle on palpation. The latter often outlasted the period of headache. Also, the masseter muscle was stiff on movement of the jaw.

Electromyograms were recorded from the temporal, occipital and nuchal areas before the ten minute period of noxious stimulation of the tooth, and during and after the headache which followed, on five occasions on subjects R and G. Evidence of transient muscular contraction was noted, but sustained exaggerated muscle potential could not be recorded in these 2 subjects following this short period of painfully noxious stimulation.

ANALYSIS OF HEADACHE FROM SUSTAINED CONTRACTION OF MUSCLES OF THE FACE, HEAD AND NECK SECONDARY TO PROLONGED NOXIOUS IMPULSES ARISING FROM THE TEETH

In contrast to the effects of brief stimulation are those of prolonged periods of noxious impulses arising from the teeth in persons who experience occipital headache and pain in the face and in the side and back of the neck, associated with dental inflammation.

Observation.—A 38 year old nurse had an "excruciating" toothache and headache of 8 to 10 plus intensity of two weeks' duration associated with osteomyelitis of the right side of the lower jaw. The headache extended from the midline of the chin along the lower jaw to the top of the right ear and into the ear, into the upper jaw, into the neck below the jaw and across the back of the head. All the lower teeth on the right ached and were tender on slight pressure. There was intense pain at the angle of the jaw, and the jaw could be opened no more than 0.5 cm. because of the contraction and extreme tenderness of the masseter muscle. A monocaine block of the mandibular nerve instantly eliminated all the pain in the face. The teeth remained tender to pressure for three to four minutes, until analgesia of the entire lower right side of the jaw was complete. Then the mouth could be opened with but

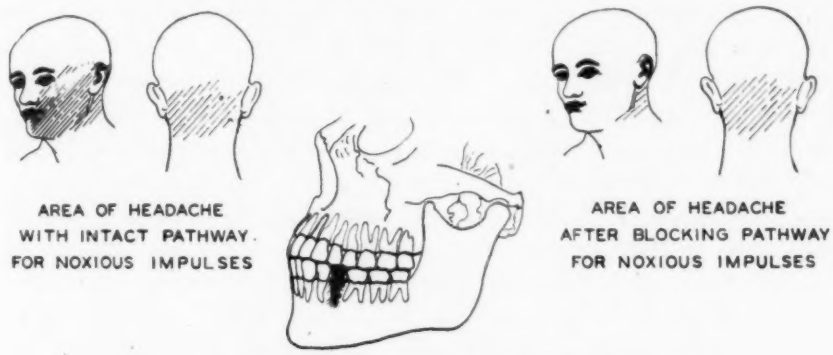


Fig. 6.—Area of distribution of headache accompanying prolonged noxious stimulation in the lower jaw (osteomyelitis), showing headache primarily due to the central spread of the effects of noxious impulses arising in the diseased tooth and headache secondarily arising from contraction of muscles in the head and neck. The former was abolished by blocking the pathway for noxious impulses, whereas the latter persisted for several hours.

slight discomfort. There remained tenderness and pain in the right side of the neck and both superficial and deep tenderness and headache over both sides of the back of the head and neck (fig. 6).

Comment.—These observations demonstrate further that the pain resulting from central spread of excitation over all sensory portions of the involved segments are immediately abolished when the primary source of noxious impulses is blocked. In addition, however, these observations show that sustained contraction of the muscles of the head and neck secondary to noxious impulses arising in any part of the head become in themselves a basis of complaint and headache.[17] These

17. Simons, D. J.; Day, E.; Goodell, H., and Wolff, H. G.: Experimental Studies on Headache: Muscles of the Scalp and Neck as Sources of Pain, A. Research Nerv. & Ment. Dis., Proc. (1942) **23**:228, 1943.

persist for some time after elimination of the primary source of noxious impulses. Such a residual muscle pain is similar to that which occurs after the vascular components of migraine headache have been eliminated by ergotamine tartrate. In the case of the teeth, this pain from sustained muscular contraction is notably in the masseter and temporalis muscles, in addition to the muscles of the occiput and neck. Occasionally, therefore, pain from such sustained muscular contraction may be a dominant feature of the discomfort from noxious impulses arising in the teeth.

Clinical Application.—Noxious impulses arising from the teeth and associated with headache, although clinically important, are not a common cause of headache. Headache due to a diseased tooth without toothache is rare. The teeth as a cause of "neuralgia" or other facial pain do not remain obscure. Despite the suggestion that dental inflammation, impaction and exposed dentine may be hidden causes of headache and other pain, clinical experience makes it appear likely that if such conditions are the sources of noxious impulses they make themselves obvious to the patient through pain induced by thermal, mechanical or chemical stimuli. Furthermore, it is possible to ascertain whether a given diseased tooth or teeth are the source of noxious impulses and the cause of headache and other pain by answering the following question: Does procainization of the tissues about the tooth or teeth in question eliminate the headache and other pain, leaving only tenderness and ache in the muscles of the neck and the back of the head? Unless the pain in the face or head is dramatically reduced or eliminated by such measures, such a tooth, even though seriously diseased, is not the cause of the headache or "neuralgia."

Certainly, recurrent or periodic attacks of headache or pain in the face or head of years' standing with intervals of complete freedom from pain in the interims between attacks cannot have their origin in morbid dental processes. Migraine, atypical "neuralgia" or major trigeminal neuralgia never stem from dental disease.

Acetylsalicylic acid, in 0.3 to 0.6 Gm. amounts every two hours; codeine, in 60 mg. amounts, or alcohol (45 per cent, as whisky), in 30 to 60 cc. amounts, alone or in combination with acetylsalicylic acid, taken every three hours, is usually adequate to eliminate headache arising from the teeth, or to make it tolerable until suitable dental procedures can be instituted to remove the source of noxious impulses or until spontaneous regression occurs. The extraction of "suspicious" or diseased teeth for the relief of headache and other head pains is not justified unless it can be demonstrated by the procedure aforementioned that the teeth are directly responsible for the pain.

SUMMARY

By noxious stimulation of healthy and diseased teeth it was possible to analyze a variety of face and head pains which stem from the teeth.

1. The initial pain induced experimentally and felt locally in a tooth had both a burning and an aching quality. The pain secondarily experienced in the head remote from the site of stimulation had only an aching quality.

2. The pain in the head associated with a prolonged toothache, and which was experienced remote from the site of noxious stimulation in the tooth, was of two varieties: (*a*) that due to central spread of excitation and experienced in tissues supplied by the same and adjacent divisions of the fifth cranial nerve, and (*b*) that due to sustained contraction of the muscles of the head and neck resulting secondarily from noxious stimuli arising in the teeth.

3. The pain experienced remote from the site of noxious stimulation in a tooth was often reduced in intensity and in area by local injection of procaine hydrochloride at the site of most intense pain, but was not eliminated.

4. All the pain experienced remote from the site of noxious stimulation in a tooth was of a steady aching quality and was eliminated by infiltration of monocaine hydrochloride about the primary source of noxious stimuli except that secondarily arising in the muscles of the head and neck as the result of sustained muscular contraction. This component slowly decreased, usually after several hours.

5. Following a period of spontaneous or experimentally induced noxious stimulation in a tooth, the pain threshold of the latter was appreciably lowered. Such lowering of the pain threshold was observed to begin several minutes after the period of noxious stimulation and progressed until ordinarily inadequate stimuli caused both local and remote pain.

6. Such effects of lowering of threshold were localized to the region of noxious stimulation and are comparable to the lowering of pain threshold that follows noxious stimulation of the skin by mechanical, thermal or chemical means.

New York Hospital.

CENTRAL COURSE OF AFFERENT FIBERS FOR PAIN IN FACIAL, GLOSSOPHARYNGEAL AND VAGUS NERVES

Clinical Observations

ALF BRODAL, M.D.
OSLO, NORWAY

THE PROGRESS of neurosurgery in modern times not only has facilitated advances in the treatment of diseases of the nervous system but has afforded possibilities for study of many problems of anatomic and physiologic interest in man. The results of surgical interventions to a certain extent may be compared with those of experimental procedures. Especially with respect to sensibility, information of considerable value may be gained from the effects of surgical procedures in man, as many sources of error are inherent in studies of this sort in animals. The present communication is concerned with an instance of this—more precisely, the distribution within the medulla oblongata of the fibers in the facial, glossopharyngeal and vagus nerves conveying impulses of pain.

In 1938 Sjöqvist [1] published a new operative procedure for eliminating pain in the face through cutting the fibers of the bulbospinal tract (descending root) of the trigeminal nerve. Anatomic studies of the trigeminus formed the basis for the operation.

Starting with the assumption set forth by Dandy,[2] that the relief of facial pain following section of the inferoposterior portion of the trigeminal root at the pons is due to the fibers conducting pain being predominantly assembled in that portion, Sjöqvist undertook an analysis of the fibers in the root of the trigeminal nerve and its branches, in order to settle whether Dandy's assumption was correct and whether other anatomic conditions might explain the failure of the operation in the hands of several neurosurgeons. From correlated anatomic and physiologic studies, it is evident that the rate of conduction in nerve fibers is dependent on their caliber (Gasser and Erlanger and associates). Furthermore, it has been established, e. g., by Zotterman,[3] that the different sensory impulses

From the Neurological University Clinic, Oslo (Prof. G. H. Monrad-Krohn, M.D.) and the Anatomical Institute, University of Oslo (Prof. Jan Jansen, M.D.).

1. Sjöqvist, O.: Eine neue Operationsmethode bei Trigeminusneuralgie: Durchschneidung des Tractus spinalis trigemini, Zentralbl. f. Neurochir. **2**:274, 1938; Studies on the Pain Conduction in the Trigeminal Nerve, Acta psychiat. et neurol., 1938, supp. 17, p. 1.

2. Dandy, W. E.: An Operation for the Cure of Tic Douloureux: Partial Section of Sensory Roots at Pons, Arch. Surg. **18**:678 (Feb.) 1929.

3. Zotterman, Y.: Specific Action Potentials in the Lingual Nerve of Cat, Skandinav. Arch. f. Physiol. **75**:105, 1936; A Note on the Relation Between Conduction Rate and Fibre Size in Mammalian Nerves, ibid. **77**:123, 1937.

are carried by fibers varying in thickness, the thinnest fibers being those devoted to the conduction of thermal and painful impulses. The last-mentioned observation has received confirmation from anatomic investigations. Thus, Windle [4] concluded that "painful afferent impulses in the trigeminal nerve probably are transmitted to a large extent by small myelinated and unmyelinated nerve fibers." This is in accordance with evidence previously brought forward by Ranson [5] in regard to the spinal nerves.

Sjöqvist, in his study of the root and the branches of the trigeminus, was unable to find any grouping or arrangement of fibers for pain and temperature in the root which could explain why a partial section of the root, as practiced by Dandy, would produce a dissociated anesthesia. Similar observations had previously been recorded by Windle.[4] However, anatomic data are known which demonstrate that these fine myelinated and unmyelinated fibers are fibers which pass to the bulbospinal tract of the trigeminal nerve (Gerard,[6] Windle [7]), and the idea of relieving trigeminal pain without causing loss of tactile sensibility in the face by cutting the bulbospinal tract occurred to Sjöqvist when he himself, in his studies of the fibers composing the tract, obtained confirmatory results. Approximately 90 per cent of the fibers in the tract were noted to have a diameter less than 4 microns.

Also, clinical observations, anatomically controlled, on patients with syringobulbia or with the Wallenberg syndrome, occlusion of the inferior posterior cerebellar artery, tend to show that the bulbospinal tract and its nucleus are concerned primarily with the conduction of impulses of pain and temperature, whereas tactile sensation is mediated by the principal sensory nucleus of the trigeminal nerve.[8] Experimentally, Gerard [6] arrived at the same conclusion after section of the spinal trigeminal tract in cats.

The operative procedure by Sjöqvist consists essentially in placing an incision in the bulbospinal tract of the trigeminal nerve immediately caudal to the lowest filaments of the vagus nerve, and a few millimeters dorsal to them, at a level corresponding approximately to the border between the middle and the caudal third of the olivary eminence. The results of the operation in 9 cases reported in his communication [1] were not satisfactory in all owing primarily to technical factors, but in all but 2 instances there resulted analgesia and thermanesthesia with preserved tactile sensibility in all, or the major part, of the area innervated by the trigeminal nerve. Similar results have been obtained by several other surgeons.[9]

---

4. Windle, W. F.: The Distribution and Probable Significance of Unmyelinated Nerve Fibers in the Trigeminal Nerve of the Cat, J. Comp. Neurol. **41**:453, 1926.

5. Ranson, S. W.: Unmyelinated Nerve Fibers as Conductors of Protopathic Sensation, Brain **38**:381, 1915.

6. Gerard, M. W.: Afferent Impulses of the Trigeminal Nerve: The Intramedullary Course of the Painful, Thermal and Tactile Impulses, Arch. Neurol. & Psychiat. **9**:306 (March) 1923.

7. Windle, W. F.: Non-Bifurcating Nerve Fibers of the Trigeminal Nerve, J. Comp. Neurol. **40**:229, 1926.

8. A survey of published cases of Wallenberg's syndrome is to be found in the paper by Gerard.[6]

(Footnotes continued on next page)

Apparently, Sjöqvist and the other authors who have practiced intramedullary tractotomy did not investigate whether the operation was followed by a similar loss of sensation in the areas of the skin and mucous membranes supplied by cranial nerves other than the trigeminus. This, however, is a point of considerable interest, for two reasons. Primarily, an investigation of this topic might give information concerning the central course of the fibers conveying impulses of pain in the facial, glossopharyngeal and vagus nerves in man. Do these fibers join the corresponding fibers from the trigeminus, partaking in the formation of the bulbospinal tract, as there is reason to believe from the phylogenetic point of view? Second, the solution of this question is of some practical relevance, since if the fibers for pain in the nerves mentioned join those in the trigeminus neuralgias of the facial, glossopharyngeal and vagus nerves may also be treated by tractotomy.

The observations on 4 patients who were subjected to intramedullary tractotomy will be reported from this point of view. The operations were performed by Dr. Arne Torkildsen, head surgeon at the neurosurgical section of the Neurological University Clinic in Oslo. It may be briefly stated that in all cases analgesia with preserved tactile sensibility appeared in the trigeminal area after operation, but this question is of no present concern.

Unfortunately, 2 of the patients had already been operated on when I first had the opportunity of examining them. Thus, a preoperative control on the sensibility of the regions of special interest for the present study was not obtained on these 2 patients. However, it is unlikely that there was any analgesia in these areas, as such slight sensory disturbances as were present in the trigeminal area previous to the tractotomy could clearly be accounted for by preceding, more peripheral, operative procedures. The sensibility for pain was tested by pinpricks of varying intensity. Care was taken not to put suggestive questions, e. g., by contrasuggestion.

REPORT OF CASES

Case 1.—R. A., a stoker aged 41, besides trigeminal neuralgia had had a recurring ventricular ulcer for several years.

---

9. Among these may be mentioned: (*a*) Rowbotham, G. F.: Treatment of Pain in the Face by Intramedullary Tractotomy, Brit. M. J. **2**:1073, 1938; (*b*) Observations on the Effect of Trigeminal Denervation, Brain **62**:364, 1939. (*c*) Smyth, G. E.: The Systematization and Central Connections of the Spinal Tract and Nucleus of the Trigeminal Nerve: A Clinical and Pathological Study, ibid. **62**:41, 1939. (*d*) Grant, F. C., and Weinberger, L. M.: Experiences with Intramedullary Tractotomy: I. Relief of Facial Pain and Summary of Operative Results, Arch. Surg. **42**:681 (April) 1941. Owing to the war, periodicals from the last years have not been accessible.

His facial pains started in 1935, when he was 32. The pains were felt in the right side of the lower jaw, from which they spread to the upper jaw and sometimes also to the temple. They occurred in paroxysms, in the beginning lasting for only a few minutes and appearing only three to four times a day. Later they occurred more frequently, became more intense and sometimes were more continuously present. Touching the face, chewing or speaking often provoked a paroxysm of pain. Vasomotor disturbances were not present. The patient consulted several physicians and dentists, had several teeth extracted and received injections in the gingiva, with only temporary improvement. After an injection of alcohol in the second branch of the right trigeminal nerve (Dr. Torkildsen), the pain in the upper jaw was absent for a fortnight but then reappeared. On this account he was admitted to the neurosurgical section on Sept. 11, 1944, for operative treatment.

Neurologic examination on his admission revealed sensory disturbances on the right side of the face. The sensitivity to superficial stimuli was slightly diminished in the area of the first branch of the trigeminus and somewhat more decreased in the distribution of the second, and the area of the third branch was nearly

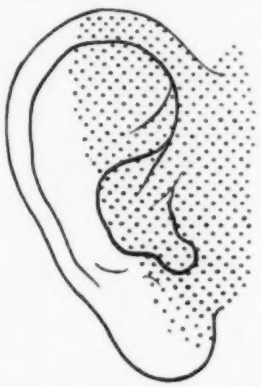


Fig. 1.—The stippled area indicates the distribution of cutaneous analgesia in the auricle in case 1, following tractotomy.

anesthetic. The corneal reflex of the right eye was slightly weakened. No signs of involvement of the motor branch of the fifth nerve were noted.

Besides these changes, there were reduction in hearing of the central, or neurogenic, type on both sides, especially the right, and a moderate increase in the proteins of the cerebrospinal fluid. Encephalographic studies with air did not give satisfactory results. No other abnormalities were revealed by neurologic, ophthalmologic and otolaryngologic examinations.

On September 14 a small suboccipital craniotomy was done and a tractotomy performed according to the method of Sjöqvist (Dr. Arne Torkildsen). The postoperative course was uneventful except for a herpetic eruption on the upper lip. Cerebellar symptoms also appeared on the right side; these, however, gradually became less conspicuous. The pains disappeared.

Postoperative examination of the sensibility of the face disclosed complete analgesia of the entire area of the trigeminal nerve on the right side of the face. The reduction of sensitivity to touch was the same as before the operation. On June 6 and Oct. 13, 1945 the patient was reexamined. On both occasions exactly similar results were obtained. The sensory changes in the face were the same as those observed during his stay in the hospital. The cutaneous area of analgesia

extended also to the auricle, where it included the entire concha practically to the anterior border of the helix (fig. 1). In the same region there was hypesthesia to cold, but the sensation of touch did not show any definite changes. There was no area of analgesia on the medial and posterior surfaces of the ear. The analgesic zone in the concha continued into the external auditory meatus, where it covered the upper, anterior and lower walls. Only in a strip along the posterior wall of the meatus was pinprick felt as painful; in the other places it was perceived as touch only. The same was true in the anterior half, approximately, of the tympanic membrane. In the mouth, there was analgesia on the right side, including the posterior third of the tongue and the soft palate, as well as the right tonsillar region and the right side of the pharynx. The corneal reflex on the right side was very weak, (+), as compared with ++ on the left side.

CASE 2.—A. H., a widow aged 53.

In 1937-1938 the patient had pulmonary tuberculosis, which since has given no symptoms.

Since January 1945 she had been troubled with facial pain, localized especially to the left side of the upper jaw. The pain, which was continuous from the begin-

Fig. 2.—The analgesic area in the auricle in case 2.

ning, in a short time spread also to the forehead and the occiput and occurred partly in paroxysms. In April the pain became so severe that she had to use morphine. At the beginning of May injections of alcohol were given in the left supraorbital nerve and the left major occipital nerve. Transitory improvement followed the injections, but as no satisfactory result was obtained she was admitted to the neurosurgical section on May 22, 1945.

Examination on admission revealed a zone of anesthesia to all superficial sensory qualities corresponding to the distribution of the left supraorbital nerve, obviously produced by the previous injection of alcohol into this nerve. Otherwise there were no sensory changes in the face, and the corneal reflexes were alike in the two eyes. There was some tenderness at the point of exit of the left major occipital nerve. Slight edema of the left upper eyelid, appearing after the injection, was noted. Except for some indication of diplopia when the patient looked downward and to the right, no abnormalities were noted at the neurologic examination, which included encephalographic studies and examination of the cerebrospinal fluid.

On May 29 a tractotomy was performed according to the method of Sjöqvist (Dr. Arne Torkildsen). The incision in the medulla oblongata was placed approxi-

mately 2 mm. rostral to the caudal end of the fourth ventricle. Shortly after the operation, the sensibility of the face was examined. The patient did not perceive pinprick as pain, but only as touch, whereas the sensitivity to touch was preserved except in the territory of the first branch of the trigeminus.

The sensory findings were confirmed several times in the following days and likewise on June 6, when she left the hospital, and, finally, on October 22. On all occasions the findings were essentially similar. There was complete anesthesia to all sensory qualities on the left side of the face in the first division of the trigeminus, extending backward to the incision made at the subtentorial craniotomy. The corneal reflex was somewhat weakened on the left side. In the territory of the second and third divisions of the trigeminus a slight hypesthesia to superficial touch was noted, whereas the sensation of pain could not be elicited at all. Pinprick was recognized but was not painful. This analgesic area extended back to the auricle and comprised most of the concha and the anterior upper part of the anthelix, with the fossa triangularis (fig. 2). There was no area of analgesia behind the ear. The appreciation of cold was not reduced in the analgesic area in this case, but according to the patient a certain degree of hyperesthesia to cold was present in this area. The external auditory meatus was analgesic except for a narrow zone on the posterior wall, and the tympanic membrane was also analgesic with the exception of the inferoposterior quadrant. Pinpricks resulting in slight bleeding from the tympanic membrane were not perceived as painful in the other three quadrants. In the mouth there was nearly total analgesia over the left half of the tongue, including its posterior third; the left half of the hard palate and the velum palatinum; the left tonsillar region, and the left half of the pharynx. The sensation of touch was alike on the two sides in the regions mentioned.

After operation cerebellar symptoms occurred in the left extremities, but they were found to be greatly diminished at the control examination in October.

CASE 3.—A. M., a married woman aged 43.

Fourteen years before her troubles started with severe pain in the left side of the face, following a dental infection. In spite of extraction of the infected tooth in the upper jaw, maxillary sinusitis ensued. This was treated surgically; despite this, there continued to be facial pain, localized to the left cheek and the temple. The pains had been continuous and more or less intense; they lasted usually for periods of one to three months, being interrupted by intervals of four weeks or less, in which she was free of pain. She had not observed special trigger points. The pains were described as throbbing and as giving a sensation like being cut with knives.

She was admitted to the neurologic clinic for the first time on Dec. 12, 1944. Neurologic examination revealed anosmia on the left side and somewhat doubtful hypalgesia in the area of the second branch of the trigeminal nerve on the left side. Otherwise the findings were normal. Roentgenographic examination of the head with the nasal sinuses and studies of the cerebrospinal fluid and the blood revealed a normal condition. A resection of the alveolar process on the upper jaw was performed. However, this did not relieve the pain, and on this account she was again admitted in May 1945. The patient was neurotic and mentally rather dull (the intelligence quotient was not determined), and as she gave the impression of exaggerating her troubles operation was postponed. However, as no improvement occurred, she was admitted for tractotomy on Oct. 10, 1945. Examination at this time revealed no change in her condition. Sensibility for pain

and touch was tested specifically in the auricle, the pharynx, the velum palatinum and the tongue and was the same on the two sides.

Tractotomy was performed on October 5 by Dr. Torkildsen. The incision was placed at the inferior end of the fourth ventricle. The sensibility of the face was determined several times during the patient's stay in the hospital and, finally, on October 22, when she left the hospital. There was nearly complete analgesia in the trigeminal area of the left side of the face with retained sensibility to touch. Pinprick was interpreted as touch but not as pain. Analgesia was present over the auricle and appeared to be complete in the concha and the adjoining regions of the antitragus and the crus helicis with the first part of the helix (fig. 3). Likewise, there was a limited area of analgesia on the medial surface of the auricle and the neighboring area of the skin covering the mastoid process. The limits of the latter area were not so sharp as in the concha. In the analgesic areas slight hypesthesia to cold appeared to be present. The external auditory meatus did not react to pain except for the posterior wall of its inner half. With

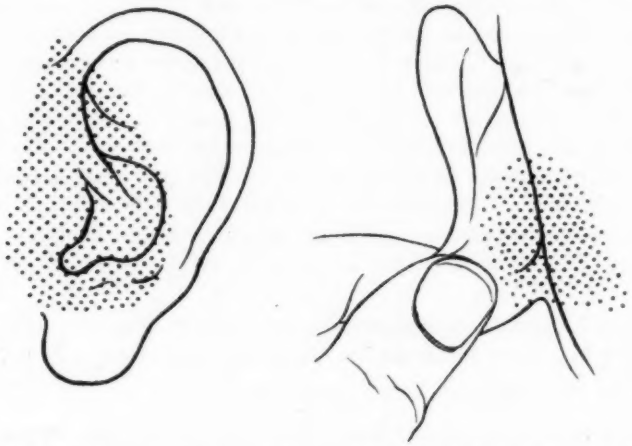


Fig. 3.—The analgesic area in the auricle and behind the ear in case 3.

respect to the tympanic membrane no definite results could be obtained, as the patient became excited during this part of the examination and probably expressed sensations of pain as soon as the membrane was touched. As previously mentioned, she was rather neurotic. With respect to the mucous membranes, the analgesia comprised the entire left half of the tongue, the inside of the cheeks, the tonsils with both palatal arches, the palate and the pharynx, all on the left side, whereas sensation of light touch was preserved. The gagging reflex appeared when the right side of the pharynx was pricked with the pin, but not when the left side was pricked.

Case 4.—K. H., a merchant aged 46.

The patient had never had any serious illness until the trigeminal pains started, two years before admission. They were localized to the right side of the face and occurred in fits of several minutes' duration a number of times each day. The pains were felt in the right cheek, and at times in the direction of the right ear and temple, and were of a stinging, sharp nature. Chewing, changes in temperature and speaking often provoked attacks. Between the fits the patient sometimes had disagreeable sensations of a "murr" type in the right cheek. Exami-

nation of his teeth and nasal sinuses, including roentgenographic studies, revealed nothing abnormal.

There had been little change in his suffering during the two years. Some time ago he had had a series of roentgen treatments of the right side of the face, but this led to only transient improvement, of approximately two weeks. As he was partially unable to fulfil his duties, he was admitted to the service of Dr. Torkildsen, who performed a tractotomy.

On his admission, on April 25, 1946, the general and neurologic examinations revealed nothing abnormal. Especially was there no sensory change in the face, the mouth and pharynx and the ear. The corneal reflexes were equal, being +(+), on the two sides. The patient was mentally alert and cooperative.

The tractotomy was performed on April 27 by Dr. Torkildsen according to the same principles as those observed with the other patients. After the operation there was complete analgesia of the entire area of the right trigeminal nerve, with possibly a faint trace of hypesthesia to touch.

On May 14 a more thorough sensory investigation showed that there was a very slight hypesthesia to touch in the right trigeminal area, as well as some

Fig. 4.—The analgesic area in the auricle in case 4.

hypesthesia to thermal stimuli, whereas the analgesia appeared to be complete. The corneal reflex was weakened on the right side, being + on the right side and + (+) on the left side.

The analgesic area extended also to the ear, comprising the concha and the adjacent regions (fig. 4). There was a narrow zone of hypalgesia on the border between the analgesic and the normal cutaneous territory. In the analgesic area a slight hypesthesia to cold was present. Behind the auricle no change could be detected. Examination of the external auditory meatus showed that the analgesia was limited to its anterior wall, whereas pinprick was conceived as painful on the posterior, upper and lower walls. The tympanic membrane exhibited analgesia in its anteroinferior quadrant.

The analgesic area in the oral cavity extended from the trigeminal area proper backward and comprised the right half of the tongue, the right tonsil and tonsillar arches, the right half of the soft palate and the right half of the posterior wall of the pharynx. Rather hard pricks with a sharp needle were not conceived as painful. Sensation to touch was alike on the two sides, and the gagging reflex could be elicited also from the analgesic area.

After the operation the attacks of facial pain disappeared. There were very slight signs of incoordination in the right upper extremity, somewhat more pronounced signs in the lower extremity and some unsteadiness of gait.

COMMENT

It is apparent from the reports that in only 1 of the 4 cases could the facial pain be spoken of as typical trigeminal neuralgia. However, the exact diagnosis of the disturbance is of little importance for the question of interest here. What is remarkable is the fact that in the 4 cases the analgesia following trigeminal tractotomy was not limited to the trigeminal area. In addition, analgesia occurred in the concha of the auricle (which, however, according to Cushing,[10] in some instances is partly supplied by the trigeminus) and in 1 case also in a small region behind the ear; furthermore, it involved the posterior third of the tongue, the tonsillar region and the pharynx, all on the side of operation. The analgesic area continued also into the external auditory meatus, covering in 3 cases approximately the upper, anterior and posterior walls, whereas in 1 case the analgesia was limited to the anterior wall, known from Cushing's work as being supplied by the trigeminal nerve. In 1 case (case 2) the analgesic area definitely exceeded the anterior part of the tympanic membrane. In 3 cases hypesthesia to cold appeared in the concha of the auricle; in the fourth (case 2), however, there was, rather, hyperesthesia for this quality over the concha. The examination of thermal sensibility requires still more mental cooperation on the part of the patient than the study of pain. None of the 4 persons examined fulfilled the conditions necessary for an exact examination of thermal sensibility. A more detailed study of these sensory qualities, especially in the regions of the mucous membranes of difficult accessibility, was not undertaken on this account. In the following discussion, therefore, mainly the relations of the pain impulses will be taken into consideration.

The distribution of the sensory fibers of the trigeminal nerve to the skin and mucous membranes has long been known from anatomic studies. Through operative section of the sensory root of the trigeminal nerve or extirpation of the gasserian ganglion, the trigeminal area has been made accessible also to clinical studies in man. Such studies have been performed by several observers. Foremost among these investigators must be mentioned Cushing, whose excellent paper published in 1904 [10] has become classic, presenting, as it does, an exact mapping of the trigeminal area. It can be regarded as an established fact that the trigeminal area in the face extends so far backward as to include the tragus and most of the crus helicis, and in some instances

10. Cushing, H.: The Sensory Distribution of the Fifth Cranial Nerve, Bull. Johns Hopkins Hosp. **15**:213, 1904.

also the first ascending part of the helix. Furthermore, as a rule, the anterior wall of the external auditory meatus is included, and probably often the anterior part of the tympanic membrane. In the mouth, the area extends as far backward as the row of the circumvallate papillae, includes the arcus glossopalatinus, except for its base, and follows the arcus to the uvula, which it covers. The distribution is entirely homolateral.

Thus, there can be no doubt that in the 4 cases reported in this paper the analgesia resulting from the section of the bulbospinal tract of the trigeminus definitely exceeds the trigeminal area proper, even if a certain allowance is made for overlap with adjoining nerves. Concerning the question as to which nerves are responsible for the additional analgesia, anatomic and clinical observations are available, although at some points there is still diversity of opinion.

Most anatomists are agreed that the glossopharyngeal nerve supplies the posterior third of the tongue not only with gustatory fibers but with fibers of general sensibility as well. Likewise, the tonsillar region and part of the pharynx are regarded as provided with fibers from this nerve. Although cutaneous sensory fibers are present in the glossopharyngeal nerve in lower vertebrates, especially in petromyzonts, plagiostomes and some of the teleosts (Ariëns Kappers, Huber and Crosby [11]), such fibers apparently have not been definitely established in higher vertebrates. In man the sensory loss following intracranial section of the glossopharyngeal nerve has been investigated in some instances. But whereas Fay [12] in a case of that type could ascertain no sensory loss except for ageusia in the posterior third of the tongue, Reichert,[13] in 4 cases of glossopharyngeal neuralgia with relief from pain after intracranial section of the nerve proximal to the ganglia, observed constant sensory loss on the posterior third of the tongue, the tonsil, the posterior part of the soft palate and the pharynx from the level of the eustachian tube to the epiglottis. A similar distribution was ascertained in 3 cases by Lewis and Dandy [14] and in 1 case described by Doyle,[15] although in

11. Ariens Kappers, C. U.; Huber, G. C., and Crosby, E. C.: The Comparative Anatomy of the Nervous System of Vertebrates, Including Man, New York, The Macmillan Company, 1936.

12. Fay, T.: Observations and Results from Intracranial Section of the Glossopharyngeus and Vagus Nerves in Man, J. Neurol. & Psychopath. **8**:110, 1927.

13. Reichert, F. L.: Neuralgias of the Glossopharyngeal Nerve with Particular Reference to the Sensory, Gustatory and Secretory Functions of the Nerve, Arch. Neurol. & Psychiat. **32**:1030 (Nov.) 1934.

14. Lewis, D., and Dandy, W. E.: The Course of the Nerve Fibers Transmitting Sensation of Taste, Arch. Surg. **21**:249 (Aug.) 1930.

15. Doyle, J. B.: Glossopharyngeal Neuralgia, Arch. Neurol. & Psychiat. **9**:34 (Jan.) 1923.

this instance the pharyngeal branch of the vagus nerve was included. After all, it appears safe to conclude that the analgesia in these regions in the 4 cases reported in this paper is due to involvement of fibers of the glossopharyngeus.

More contradictory are the views concerning the sensory fibers of the nervus facialis. In 1907 Ramsay Hunt [16] drew attention to the distribution of the vesicles in herpes zoster oticus to the outer surface of the auricle, especially to the concha, to a limited area behind the auricle and to the palate and anterior two thirds of the tongue. Hunt maintained that the localization of the vesicles, as well as of pain, in that form of neuralgia which he termed geniculate neuralgia demonstrated the cutaneous distribution of the fibers of the nervus intermedius. This nerve, according to Hunt, must have other functions besides conveying gustatory and secretory fibers. Although new cases of so-called geniculate neuralgia were reported repeatedly in the following years by himself and other authors, his opinions [16] were violently attacked, chiefly, as it appears, because unequivocal anatomic verification of the occurrence of cutaneous fibers in the facialis-intermedius system in man was lacking. However, data from comparative anatomy do not make it unlikely that in man the facial nerve (the intermedius) may have a vestigial cutaneous component, as such is the case in lower vertebrates, e. g., plagiostomes, amphibia (Herrick,[17] Norris [18] and others), and in 1919 Rhinehart [19] was able to demonstrate that in the mouse some fibers from the nervus intermedius are distributed to the skin of the auricle. This "ramus cutaneus facialis" joins the ramus auricularis vagi, well known to the old anatomists, and the fibers of the two nerves intermingle. In 1928 Larsell and Fenton [20] demonstrated in a human fetus of 54 mm. a cutaneous branch of the seventh nerve with a course and termination corresponding to that shown in the mouse by Rhinehart. Thus, it can now scarcely be doubted that also in man the nervus intermedius carries some somatic sensory fibers, ending in the concha of the auricle and having their perikarya in the geniculate ganglion.

---

16. Hunt, J. R.: Herpetic Inflammation of the Geniculate Ganglion: A New Syndrome and Its Complications, J. Nerv. & Ment. Dis. **34**:73, 1907; Geniculate Neuralgia (Neuralgia of the Nervus Facialis), Arch. Neurol. & Psychiat. **37**:253 (Feb.) 1937.

17. Herrick, C. J.: The Medulla Oblongata of Larval Amblystoma, J. Comp. Neurol. **24**:343, 1914.

18. Norris, H. W.: The Cranial Nerves of Siren Lacertinus, J. Morphol. **24**:245, 1913.

19. Rhinehart, D. A.: The Nervus Facialis of the Albino Mouse, J. Comp. Neurol. **30**:81, 1919.

20. Larsell, O., and Fenton, R. A.: The Embryology and Neurohistology of the Sphenopalatine Ganglion Connections: A Contribution to the Study of Otalgia, Laryngoscope **38**:371, 1928.

The distribution of cutaneous fibers of the vagus (ramus auricularis) to the same field, and eventually also to a limited area at the dorsomedial surface of the auricle, must be regarded established. It appears that this area is provided with cutaneous fibers from both the seventh and the tenth nerve. Cushing [10] observed that after section of the ventral cutaneous branches of the superior cervical nerves in man the concha of the auricle retained its normal sensibility, representing thus an area interposed between the trigeminal and the cervical cutaneous areas. Cushing was inclined to attribute the remaining sensibility in these instances to the vagus. However, it must be admitted that observations of this type do not decide the question whether the vagus or the facial nerve or both are responsible for the innervation of the cutaneous area in question. Neither do the experiments by Sherrington [21] in the macaque, as he himself was aware, carry one beyond the fact that there is a field interposed between the trigeminal and the cervical area. The region with remaining sensibility following section of the trigeminal and the upper cervical roots, according to Sherrington, "takes in practically the whole of the concha, the antitragus, part of the tragus and part of the antihelix; also part of the fossa of the antihelix." The slightly larger extension of the area in the macaque may perhaps be accounted for by difficulties involved in determining exact limits in the experimental animal. Clinical proof that the vagus really participates in the innervation of this field requires the section of one vagus nerve, an operation which, for obvious reasons, is not frequently undertaken. However, a case of this type has been reported by Fay.[12] In his case 2 the vagus and the trigeminal nerve were sectioned on the same side, with a resulting anesthesia which, in addition to the trigeminal field, included the concha, part of the anthelix and a small area behind the ear. In his case 1, in which the fifth, ninth and upper cervical nerves were sectioned, the areas on the auricle remained intact. It may be mentioned in this connection that Clark and Taylor,[22] in a case of geniculate neuralgia with section of the pars intermedia of the facial nerve, obtained relief from pain. Yet they could not ascertain any sensory loss in the ear three days after the operation.

Whether it is in some instances the vagus, in others the facialis or in still others both of them which in man provides the concha, and eventually a little more of the auricle, with cutaneous fibers, the fact of prime interest to the question treated in this communication is that

21. Sherrington, C. S.: Experiments in Examination of the Peripheral Distribution of the Fibers of the Posterior Roots of Some Spinal Nerves: II., Phil. Tr., London, s.B **190**:45, 1898; abstracted, Proc. Roy. Soc., London **60**:408, 1896-1897.

22. Clark, L. P., and Taylor, A. S.: True Tic Douloureux of the Sensory Filaments of the Facial Nerve, J. A. M. A. **53**:2144 (Dec. 25) 1909.

this area is not supplied by the trigeminus. From the findings in these 4 cases in which the tractotomy of Sjöqvist was done, it is clear that the pain impulses from this area of the auricle must join those from the trigeminal field proper, traveling in the bulbospinal tract. The same holds good for the pain-conducting fibers from the posterior third of the tongue, the palatine arches, the tonsil and the pharynx. The fibers from these parts of the mucous membranes probably are conveyed by the glossopharyngeus, there being left open, however, the possibility that some of them take their route through the vagus, usually assumed to partake in the innervation of the pharynx.

The observations concerning the pain fibers to the external auditory meatus and the tympanic membrane in these cases are not wholly satisfactory. In 1 (case 3) the information was unreliable on account of the patient's mental state. In the 3 other cases, however, the areas mentioned by Cushing [10] as supplied by the trigeminal nerve were analgesic. In case 4 the analgesia was limited to this area—the anterior wall of the meatus and the anterior part of the membrane—whereas in the other 2 cases the analgesic area was considerably larger, leaving only a strip on the posterior wall of the meatus and approximately the inferoposterior quadrant of the tympanic membrane with normal sensibility to pain. It is not possible on the basis of these observations to decide whether or not the larger extension is only an expression of individual variation. Considering the constant findings of Cushing, it appears likely that the wider area of analgesia in cases 1 and 2 might be due to a participation of the seventh and/or the tenth cranial nerve in the sensory supply of the external auditory meatus and the tympanic membrane.

From the phylogenetic point of view, the conclusions set forth here appear valid, in accordance with the doctrine of nerve components, i. e., that fibers conveying the same type of impulses have a tendency to pass to the same nucleus. In fact, fibers entering with the seventh, ninth and tenth cranial nerves and joining the bulbospinal tract of the trigeminal nerve (descending root of the trigeminus) have been described in several vertebrates. This is the case in cyclostomes (Jansen,[23] Woodburne [24]). In ganoids fibers from the glossopharyngeus and the vagus can be seen to penetrate the descending root of the trigeminus and probably contribute to it (Johnston,[25] Woodburne [24]). In teleosts Herrick [26] and Woodburne described such fibers from the

23. Jansen, J.: The Brain of Myxine Glutinosa, J. Comp. Neurol. **49**:359, 1930.

24. Woodburne, R. T.: A Phylogenetic Consideration of the Primary and Secondary Centers and Connections of the Trigeminal Complex in a Series of Vertebrates, J. Comp. Neurol. **65**:403, 1936.

25. Johnston, J. B.: Brain of Acipenser, Zool. Jahrb. Abt. f. Anat. **15**:59, 1901.

26. Herrick, C. J.: The Cranial and First Spinal Nerves of Menidia: A Contribution upon the Nerve Components of Bony Fishes, J. Comp. Neurol. **9**:21, 1899.

vagus. In amphibia several authors have observed fibers of this type—e. g., Norris,[18] from the facial nerve; Woodburne,[24] from the facial and vagus nerves, and Herrick,[27] from the glossopharyngeal nerve as well. In reptiles, as well as in birds, Woodburne noted such fibers from the vagus. As concerns mammals (mouse and rabbit), Woodburne, who has recently undertaken an investigation of the trigeminus [24] from the phylogenetic standpoint, stated (page 487):

> The sensory roots of the glossopharyngeal and the vagus nerves pass through the dorsal portion of the descending root and there appear to be contributions from these nerves to the root.

Obviously, human material is difficult to analyze on this point, the fibers in question constituting only a modest part of the entire root. So far as is known, direct observations on human material are lacking concerning an eventual contribution to the bulbospinal tract of the trigeminus by the facial, glossopharyngeal and vagus nerves. The observations reported in this paper form a clinicoanatomic argument in favor of the presence of such fibers. From the observations in the 4 cases reported here, nothing definite can be said concerning the exact terminal area of the seventh, ninth and tenth nerve fibers within the nucleus of the bulbospinal tract. As recently emphasized by Smyth,[9c] the weight of evidence favors the conception that the ophthalmic fibers terminate most caudally and the mandibular fibers rostrally within the nucleus.

Another inference which can be drawn from these findings is of a practical clinical nature. Obviously, they tend to widen the range of application of the tractotomy of Sjöqvist. It is to be assumed that this operation might give satisfactory results not only in cases of trigeminal neuralgia but in those of glossopharyngeal, vagal and geniculate neuralgia. Especially in the case of geniculate neuralgia, the tractotomy appears preferable to intracranial section of the seventh nerve, the first procedure being more easily performed and having the advantage of attacking only the pain, without disturbing the other functions of the nerve and without endangering the eighth nerve. However, it must be borne in mind that the indications for performing a tractotomy are somewhat more restricted than those for section of the root, at least of the trigeminus. Furthermore, it appears that after a time a certain degree of facial dysesthesia may occur in some instances.

A problem of more anatomic interest which requires consideration on the basis of the observations reported concerns the criteria for the differentiation between somatic afferent and general visceral afferent fibers and qualities. This matter, however, will not be discussed in this connection.

---

27. Herrick, C. J.: The Medulla Oblongata of Necturus, J. Comp. Neurol. **50**:1, 1930

SUMMARY AND CONCLUSIONS

In 4 cases of trigeminal neuralgia in which the tractotomy of Sjöqvist (section of the bulbospinal tract of the trigeminus) was performed the ensuing sensory loss was studied. It is shown that in addition to the analgesia with retained tactile sensibility in the trigeminal area of the face and mouth, known to follow the operation, similar sensory changes occur in other regions. These regions are the concha of the auricle, with more or less of the neighboring part of the anthelix (figs. 1 to 4), the posterior third of the tongue, the tonsils and the pharynx, all on the side of operation. In 1 case, also, a small area behind the ear was included, and in 2 cases the analgesia extended to the posterior, upper and anterior walls of the external auditory meatus. According to previous anatomic and clinical investigations, the regions mentioned are innervated by the seventh, ninth and tenth cranial nerves.

From these observations, it is concluded that the fibers conducting pain impulses in the facialis-intermedius complex, the glossopharyngeus and the vagus join the pain fibers of the trigeminus and accompany them in the bulbospinal tract of the trigeminal nerve (tractus spinalis nervi trigemini, descending root of the trigeminus).

It appears from these observations that neuralgias of the seventh nerve (geniculate neuralgia of Ramsay Hunt), as well as those of the ninth and tenth nerve, may be successfully treated by tractotomy (Sjöqvist), and thereby certain complications not infrequently met with after intracranial section of the nerves in question, especially of the facialis and vagus, avoided.

Department of Human Anatomy, University Museum, Oxford, England.

MENINGEAL REACTION WITH ABSCESS OF THE BRAIN

BERNARD J. ALPERS, M.D.
AND
FRANCIS M. FORSTER, M.D.
PHILADELPHIA

IT IS surprising that relatively little attention has been given to the meningeal reaction associated with abscess of the brain, despite the fact that the clinical diagnosis of brain abscess is often concerned with this feature of the problem. A great deal is known concerning the processes involved in the encapsulation of a brain abscess, but much less is known concerning the reaction in the meninges.

The following study was undertaken in order to determine (1) the reaction of the meninges overlying an abscess of the brain and (2) its relationship to the general problem of diagnosis of abscess and to the process of encapsulation in particular.

MATERIAL AND OBSERVATIONS

Histopathologic studies were made of the meninges in 19 cases with 42 brain abscesses. No cases of generalized purulent meningitis were included in this series. The table presents the results of the study of the meninges, together with relevant data on the patients and the cerebral abscesses. In all but 1 instance (case 18) evidence of meningitis was observed. The inflammatory changes in the meninges were focal and occurred adjacent to or in the neighborhood of the abscess. The proximity of the abscess to the meninges bore some relation to the degree of meningitis present. When the abscess approached the pial border, focal meningitis was well marked, while with the abscess at an appreciable distance from the meninges the inflammatory changes in the meninges were definite but less marked. It was not necessary, however, for the cerebral abscess to abut directly on the sulcal meninges in order to produce inflammatory changes, for an appreciable amount of normal white matter and cortex might intervene between the focal meningitis and the most external portion of the cavity of the abscess.

The focal meningitis encountered in sulci neighboring brain abscesses varied in type from acute purulent to chronic adhesive meningitis. In the acute purulent type the meninges in the sulci were increased

From the Department of Neurology, Jefferson Medical College.
Read at a meeting of the Philadelphia Neurological Society, March 22, 1946.

Clinical and Pathologic Data on a Series of Cases of Brain Abscess

Case No.	Age, Yr.	Duration of Symptoms of Abscess *	Source of Cerebral Abscess †	Cerebral Abscess		Meningeal Changes §		
				Location	Capsule ‡	In Sulci Near Abscess	Sulcal Sealing	In Distant Areas
1	50	4½ mo.	Cryptogenic	Cerebral	+++	Fibrous	++	None
2	31	7 days	Otitis media	Cerebral	—	Acute	+	Few lymphocytes
3	31	3 wk.	Otitis media	Cerebellar	—	Acute	++	None
4	43	—	Frontal sinusitis	Cerebral	+++	Acute	++	None
5	23	—	Osteomyelitis of femur	Cerebral	—	Acute	+	Few lymphocytes and phagocytes; occasional polynuclear
6	38	3 wk.	Frontal sinusitis	Cerebral	—	Acute	+	Few lymphocytes
7	57	4 days	Pulmonary empyema	Cerebellar; cerebral	—	Acute	+	None
8	34	—	Bronchiectasis	Cerebral	+	Subsiding acute	++	None
9	38	—	Cryptogenic	Cerebral	+++	Fibrous with few lymphocytes	++	Scattered lymphocytes, few
10	35	11 days	Bronchiectasis	Cerebral	++	Subsiding acute	++	None
11	39	—	Pulmonary abscess	Cerebral	+	Acute	+	None
12	36	26 days	Pulmonary abscess	Cerebral	++	Fibrous with few lymphocytes	+	None
13	14	3 wk.	Frontal sinusitis	Cerebral	—	Subsiding acute	+	Moderate lymphocytic infiltration
14	13	9 days	Tetralogy of Fallot: endocarditis	Cerebral	+++	Fibrous	+	None
15	21	—	Otitis media	Cerebellar	+++	Fibrous	++	None
16	46	7 days	Pulmonary empyema	Cerebral	++	Fibrous	+	Occasional lymphocyte
17	44	18 days	Otitis media	Cerebral	++	Lymphocytic infiltration	+	None
18	40	7 days	Otitis media	Cerebral	++	None	0	None
19	17	34 days	Bronchiectasis	Cerebral	++	Lymphocytes and occasional polynuclear cell	+	None

* The minus sign indicates that there was no clinical evidence of cerebral abscess.

† This column presents the infectious processes observed clinically and at autopsy from which the cerebral abscess arose. Cryptogenic indicates that no source was found.

‡ The degree of encapsulation of the abscess is indicated. The minus sign indicates that there was no reparative process of any degree; the number of plus signs indicate the degree of encapsulation with fibrous and glial tissue.

§ "Acute" indicates acute inflammatory changes with polymorphonuclear cells and fibrin. "Subsiding acute" indicates the presence of some polymorphonuclear cells, well developed phagocytosis and some lymphocytic reaction. The presence of "lymphocytes" or "lymphocytic infiltration" with occasional polymorphonuclear cells was considered to represent a later transitional stage. "Fibrous" indicates dense collagenous tissue formation in the meninges, with adhesions to the cortex and a minimum number of lymphocytes. "Sulcal sealing" refers to the state of development of the limitation of inflammation to the depths of the sulci and the retention of a normal state of the meninges over the crown of the gyrus. The last column presents the presence or absence of inflammatory infiltration of the leptomeninges in sections at a distance from the abscess.

in thickness to four to five times the normal and were infiltrated with polymorphonuclear cells and with heavy depositions of fibrin. The cellular infiltration was dense, and the individual polymorphonuclear cells were well preserved. In the acute stages there was no evidence of resolution or of reparative processes. In the chronic adhesive type of meningitis the sulcal meninges were normal or slightly increased in breadth. Demarcation between the pial border and the arachnoid was impossible, and the entire expanse of the leptomeninges was dense fibrous tissue. In this type of change cellular infiltration of the meninges was slight and almost entirely lymphocytic. Only an occasional poly-

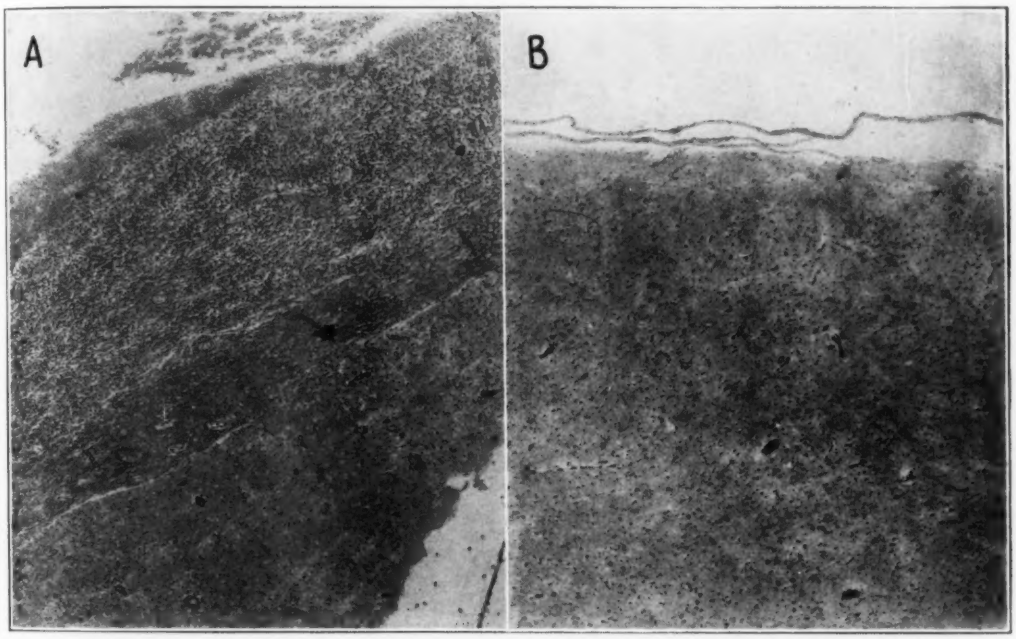


Fig. 1.—*A*, acute purulent meningitis in the vicinity of a cerebral abscess. The meninges are thickened and contain fibrin and leukocytes. *B*, normal state of the meninges over the cerebral cortex at a distance from the abscess. Hematoxylin and eosin stain; × 30.

morphonuclear leukocyte or histiocytic phagocyte was encountered. Between these two extremes of acute inflammation and chronic adhesive change there existed various intermediary stages, illustrating well the reparative process within the sulcal meninges. In the cases in which the condition was described as subsiding acute meningitis, some polymorphonuclear cells were encountered; these cells were frequently in states of poorer preservation than the cells seen in the acute stage. Some fibrin and debris were present. The cellular infiltration also included a fair proportion of lymphocytes and many histiocytic phagocytes, which contained debris. Occasionally in these subsiding states a few fibro-

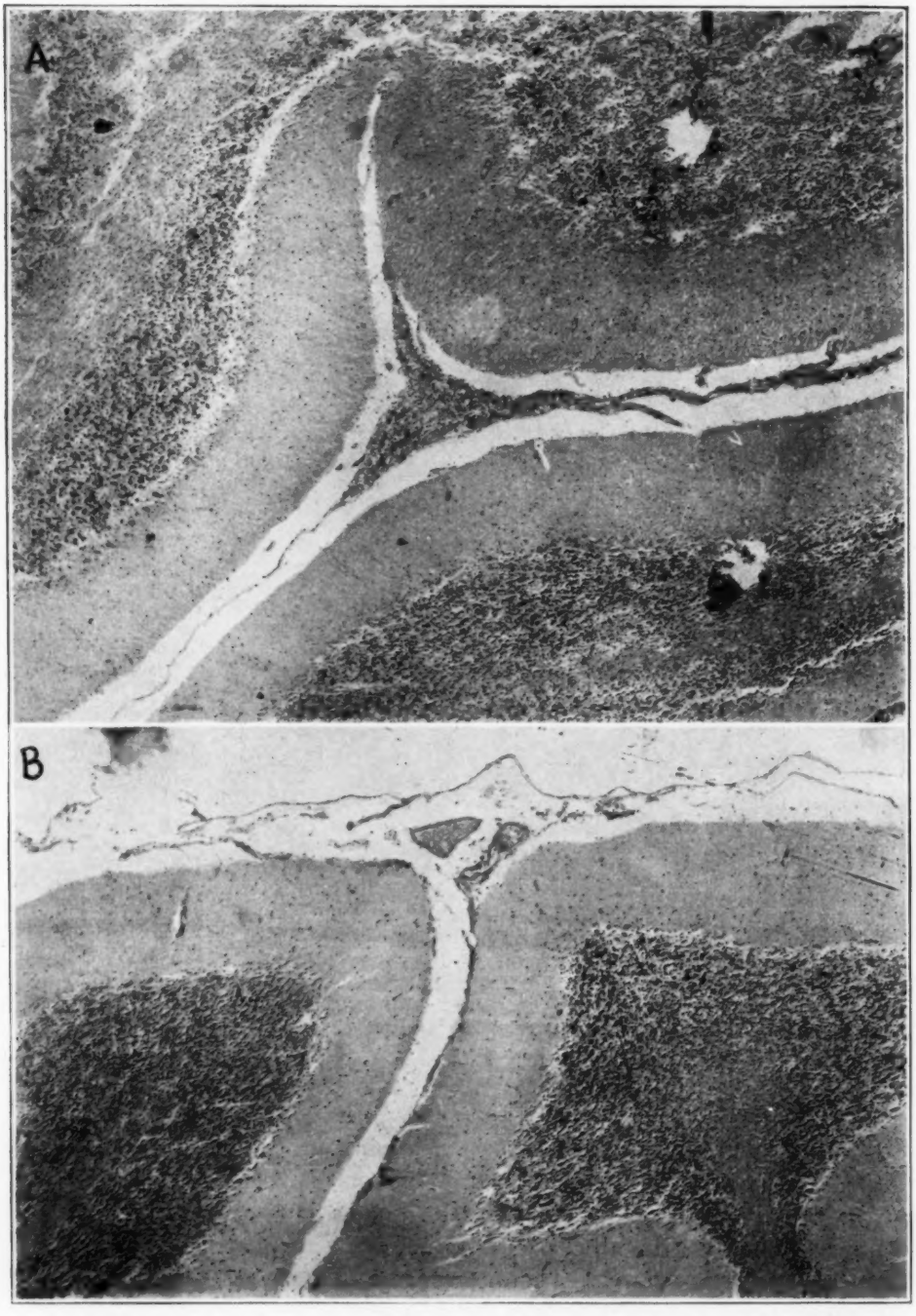


Fig. 2.—*A*, acute inflammation of the meninges in a sulcus of the cerebellum and adjacent to an abscess in the white matter. *B*, normal meninges in the sulcus and over the cerebellar folia adjacent to the folium containing the abscess. Hematoxylin and eosin; × 35.

blasts could be seen in the meninges, thus evidencing the beginning of the chronic state. It was not possible from the material at hand to determine definitely the origin of the fibroblasts, i. e., whether they arose from the pia or from the adventitia of the blood vessels. The meningeal blood vessels in all stages of the meningitis were well preserved, and no cellular infiltration of the vessel walls was encountered.

The inflammatory changes in the meninges adjacent to the cerebral abscesses were in striking contrast to the state of the meninges elsewhere. In 13 cases the meninges at a distance from the abscess were free of cellular infiltration and were in all respects normal. In the remaining 6 cases a moderate number of lymphocytes were scattered through the interstices of the meninges, and in 3 of the 6 cases the cellular infiltration included a few polymorphonuclear cells. In the 6 cases with some cellular infiltration of the meninges at a distance from the abscess, the meninges were not increased in thickness and contained no fibrin or debris, and the cellular infiltration was moderate in degree and in variance to the state of the meninges adjacent to the abscess. This striking difference between the state of the meninges in the neighborhood of the cerebral abscess and over distant portions of the central nervous system indicated that a limiting process had occurred somewhere, with a resultant sealing off of the meningitis. This limitation of the spread of the meningitis takes place for the most part at the apex of the sulcus, where the meninges leave the sulcus and pass over the crown of the cerebral or the cerebellar convolution. The acute type of focal meningitis best demonstrates this limitation of the inflammation, for in this condition the sulcal meninges are greatly thickened and contain a heavy infiltration with polymorphonuclear leukocytes, deposition of fibrin and debris formation. This extends for a considerable distance along the sulcus and reaches the apex, but at the point where the meninges veer to cover the crown of the convolution the acute inflammatory changes halt abruptly, the meninges approach normal thickness, the deposition of fibrin is absent and instead of the vast number of polymorphonuclear leukocytes a few lymphocytes and an occasional polymorphonuclear leukocyte are present. While the inflammatory process in the meninges is thus prevented from spreading through the meninges over the convolutions, there is another but less definite limitation of the spread of the inflammation along the sulcal meninges. In those sections containing a long sulcus with an abscess near the center of the sectioned portion of the sulcus, the meningeal changes were more pronounced in the sulcal meninges near the abscess and less intense in each direction at a distance from the abscess. This was true of the acute, the chronic and the intermediary type of inflammation. These alterations in the degree of inflammation were not so sharply defined as those occurring at the apex of the sulci. In the depths of the sulci,

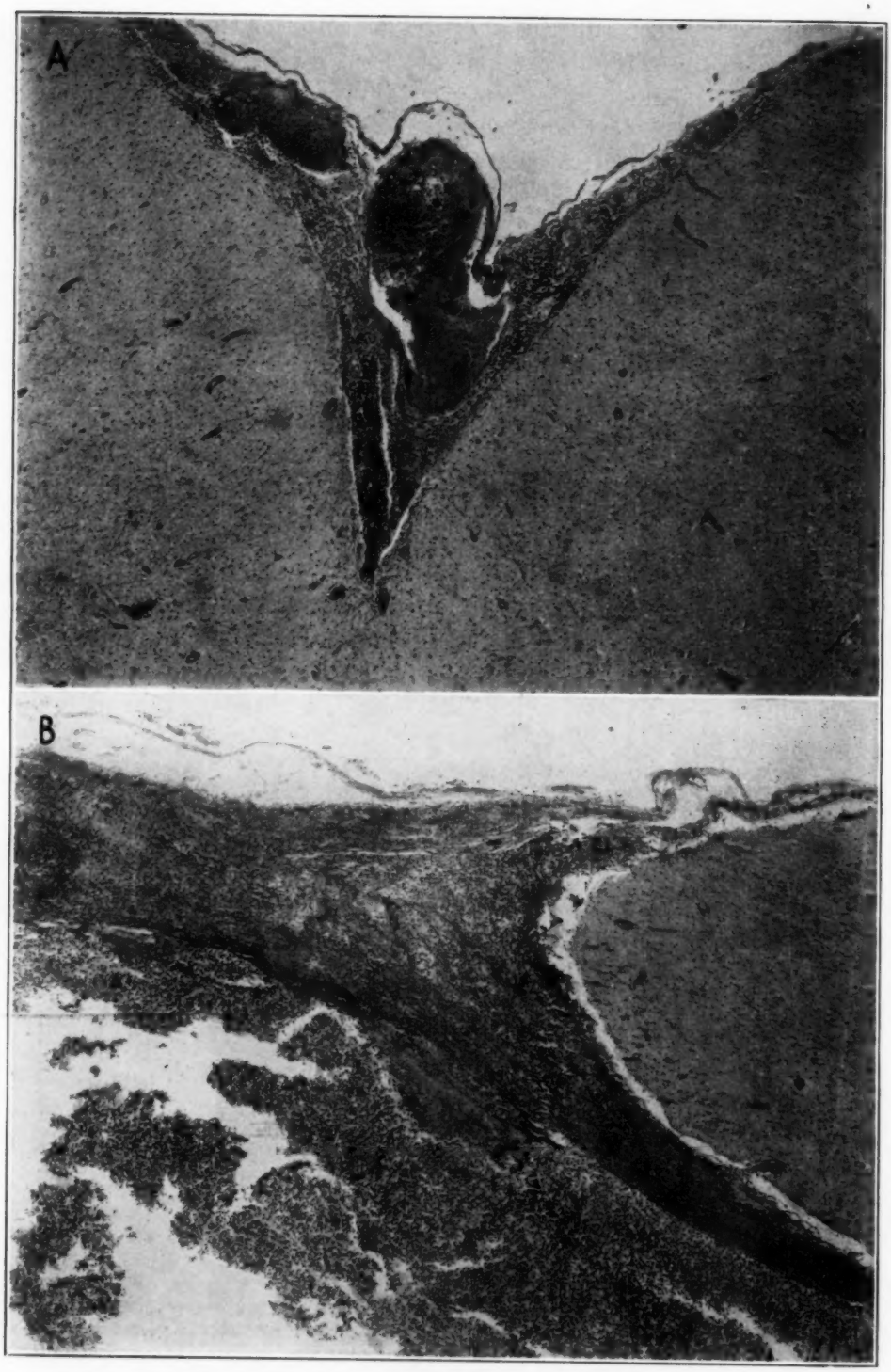


FIGURE 3
(See legend on opposite page)

when an acute inflammatory change was present it extended along the entire sulcal meninges, but in the neighborhood of the abscess the meninges were thicker, and fibrin, debris and polymorphonuclear leukocytes were more prevalent, than at a distance. No variation in the stage of meningitis in a given sulcus was encountered. A sulcus presenting acute alterations nearest the abscess showed acute changes at a distance but of less marked degree. The meningitis associated with brain abscess is restricted to a focal inflammation by the sharp limitation against spread of the process from the sulci to the meninges over the convolutional crowns and by the gradual decrease in the degree of inflammation within the sulci.

The efficacy of this protective function of the meninges can best be appreciated in those cases in which the abscess closely approximates, or even involves, the pia. In such instances (fig. 3 *B*) the meninges near the abscess presented the acute inflammatory changes, but both methods of restricting the spread of the inflammation were effective in preventing generalized meningitis.

The stage of inflammation in the meninges could be correlated rather well with the degree of encapsulation of the abscess. In the 6 cases of acute abscess with no evidence of encapsulation the meningeal changes were of the acute inflammatory type. In 1 of these instances the meningitis gave indication of subsiding, for some phagocytic activity was taking place. The well encapsulated abscesses were accompanied with chronic meningeal changes with 1 exception (case 18), in which the meningeal changes were acute. In this particular instance there were pronounced perivascular infiltrations in the white and the gray matter lying between the capsule of the abscess and the meninges. The correlation between the capsule of the abscess and the type of meningitis indicates that acute abscesses are accompanied with acute focal meningitis, that this meningitis may begin to subside before definite encapsulation occurs but that by the time well defined encapsulation occurs the meningitis has usually become chronic.

COMMENT

The localized meningeal reaction associated with brain abscess has its importance from the standpoint both of its histologic features and of its clinical significance. Relatively little attention has been given to the

Fig. 3.—*A*, limitation of inflammation to the meninges in the sulcus. The abscess lies deep in the white matter and beyond the limits of the illustration. As the meninges approach the crown of the convolution, inflammation decreases. *B*, limitation of inflammation to the meninges in the sulcus. The abscess is superficial and extends through the cerebral cortex. The degree of meningitis is greatly decreased over the crown of the adjacent convolution. Hematoxylin and eosin; × 35.

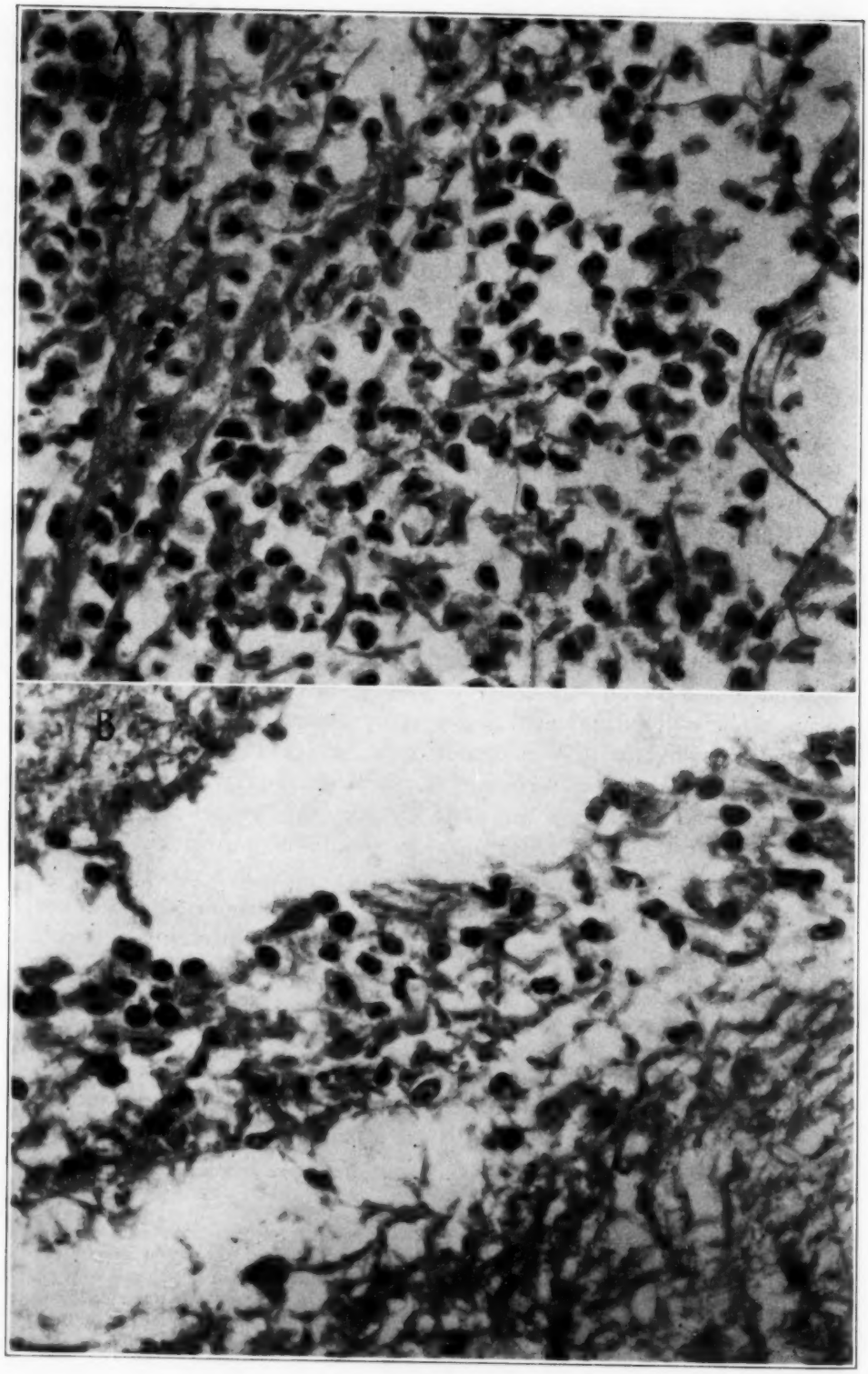


FIGURE 4
(See legend on opposite page)

histologic reaction of the meninges accompanying cerebral abscess, though much has been said concerning the cellular response in the spinal fluid. A survey of the many investigations on the histology of brain abscess disclosed no mention of the meningeal reaction in most cases. Homén [1] called attention to the fact that the meninges overlying the abscess are often involved, that the changes are often confined to the region of the abscess or that the process may spread for a short distance beyond this.

Histologic Features.—From the purely histologic standpoint, several features emerge from our study: 1. A localized meningeal reaction is present in practically every case of brain abscess. In only 1 of 42 abscesses in our series was such a reaction not observed. The reaction varies in content and in the type of cell, depending on the acuteness of the process, being in some instances predominantly polymorphonuclear and in others lymphocytic. 2. The reaction is confined to the overlying gyri and fades off rapidly, so that adjacent gyri reveal no infiltration. Studies of the cortex reveal that only the gyri immediately above the abscess are involved and that adjacent and distant gyri are clean. The meningeal reaction associated with brain abscess is, therefore, in the beginning a localized process, which may in some instances become generalized. 3. The process of localization appears to be accomplished by a limiting process which tends to confine the reaction to the region contiguous to the abscess. The meningeal reaction is confined largely to the sulcus, and the process is sealed off by a meningeal reaction, which prevents spread of the process to adjacent areas. A similar process of limitation was observed by Carmichael, Kernohan and Adson,[2] who stated:

> Abscesses enlarging so as to approach the pial or ependymal surfaces of the brain may give rise to meningitis, although in this instance it is more usual to observe that the enlarging lesion, which is somewhat circumscribed, produces adhesive arachnoiditis, which has the effect of excluding the subarachnoid space and thereby safeguards the organism from meningitis.

1. Homén, E. A.: Experimentelle und pathologische Beiträge zur Kenntnis der Hirnabszesse, ihrer Entstehung und Weiterentwicklung mit spezieller Berücksichtigung der dabei auftretenden Zellformen, Arb. a. d. path. Inst. d. Univ. Helsingfors **1**:1-80, 1913.

2. Carmichael, F. A., Jr.; Kernohan, J. W., and Adson, A. W.: Histopathogenesis of Cerebral Abscess, Arch. Neurol. & Psychiat. **42**:1001-1029 (Dec.) 1939.

Fig. 4.—Photomicrographs taken with a high power lens of portions of the field in figure 3 *B*, showing inflammatory changes in the meninges. *A* shows acute inflammatory changes, with fibrin and polymorphonuclear leukocytes, in the sulcus adjacent to the cortical abscess. *B* illustrates moderate lymphocytic and fibroblastic response occurring at the crown of the next convolution, where the meningitis is limited in its spread. Hematoxylin and eosin stain; × 350.

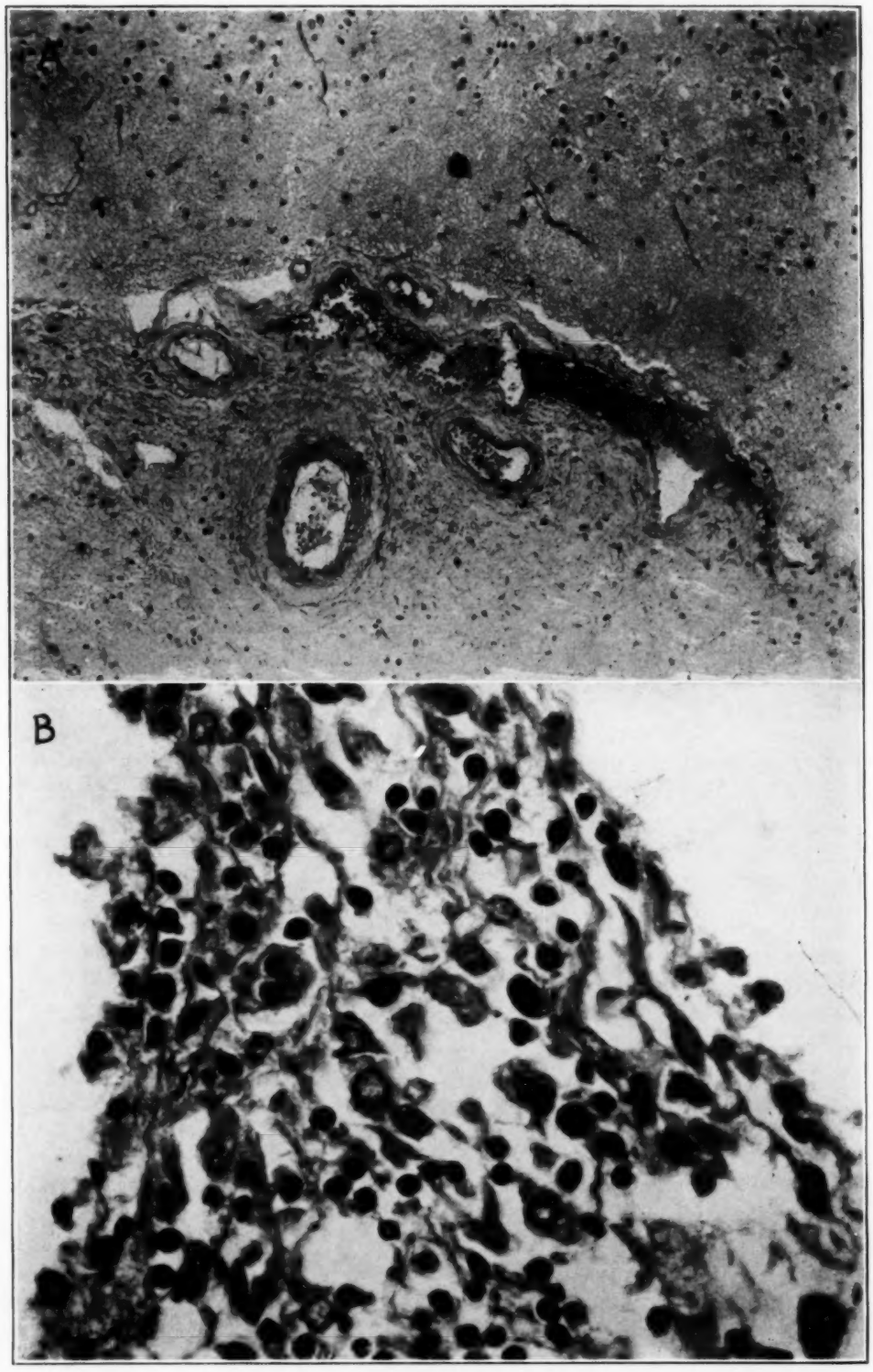


FIGURE 5
(See legend on opposite page)

A limiting reaction similar to that found with brain abscess has been described also in cases of subarachnoid hemorrhage (Alpers and Forster [2a]).

No bacterial stains were made on our material, so that nothing can be said about the occurrence of bacteria in the meningeal reaction. It is assumed that no bacteria are present, but the circumstances may not always be the same. The probabilities are that the localized meningeal reaction over an abscess is sterile, while generalized meningitis is not, since it is produced by direct extension of the infection from the abscess itself.

The localized meningeal reaction must be regarded as a secondary process, indicative of the underlying inflammation. It is produced by spread along the vessels toward the subarachnoid space, as indicated by Piquet and Boury.[3]

Then meningeal reaction overlying the brain abscess mirrored with fair accuracy the process of encapsulation of the abscess itself. In general, the meningeal reaction was more profuse and was of a polymorphonuclear type in the acute stages of the abscess and tended to become less pronounced and to take on a lymphocytic formula as the abscess became more chronic and was walled off. The table illustrates the relationship of the meningeal reaction to the process of encapsulation.

Clinical Features.—Correlation of the histologic features of brain abscess and the spinal fluid cell count is desirable to facilitate diagnosis. It is reasonable to assume that a meningeal reaction will be associated with an increase of cells in the spinal fluid, which theoretically should parallel the changes in the meninges. A correlation of this sort was attempted by Woltman,[4] who observed that the number of neutrophils in the spinal fluid became reduced after the formation of a brain abscess got under way and that a persistence of neutrophils suggested that encapsulation was progressing unfavorably. On the other hand, a small number of lymphocytes in the spinal fluid seemed to indicate better

2a. Alpers, B. J., and Forster, F. M.: The Reparative Process in Subarachnoid Hemorrhage, J. Neuropath. & Exper. Neurol. **4**:262, 1945.

3. Piquet, J., and Boury: Contribution à l'étude histologique de l'abcès cérébral, Ann. d'oto-laryng., November 1936, pp. 1113-1143.

4. Woltman, H. W.: Spinal Fluid Cell Count and Encapsulation of Brain Abscess: Attempt to Correlate These Factors, and to Determine Optimal Time for Drainage, J. A. M. A. **100**:720-722 (March 11) 1933.

Fig. 5.—Chronic fibrous type of leptomeningitis occurring in the vicinity of an old and well encapsulated abscess. *A*, × 35. *B*, × 350, reveals lymphocytosis, some phagocytosis, fibroblasts and collagen. Hematoxylin and eosin stain.

encapsulation and greater resistance. Grant [5] asserted that "a fluid which is almost always sterile and shows a relatively low cell count suggests abscess."

Studies of the spinal fluid were available in only 7 cases of our series. The number of spinal fluids available for study makes impossible a careful correlation, but it appears to be true that the cell count is higher

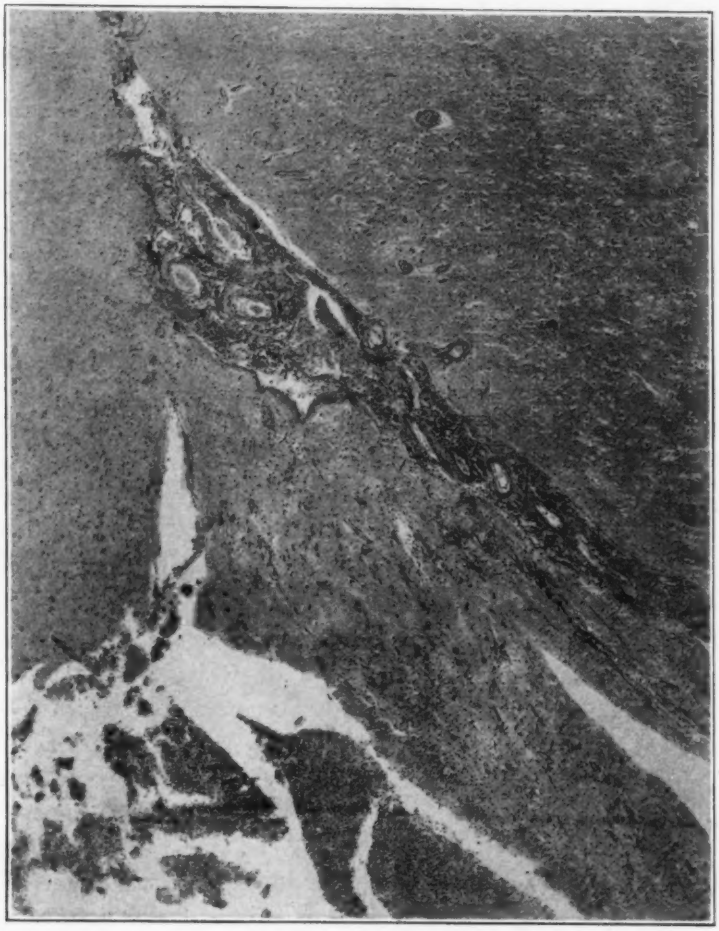


Fig. 6.—Meningitis in the sulcus in the vicinity of a cerebral abscess. The degree of meningitis decreases in each direction from the abcess. Hematoxylin and eosin stain; × 35.

with the acute abscess and lower with the more chronic abscess. As Woltman predicted in purely clinical studies, the level of the cell count and the nature of the cells in the spinal fluid are fairly accurate indi-

5. Grant, F. C.: Brain Abscess: Collective Reviews, Internat. Abstr. Surg. **72**:118-138, 1941; in Surg., Gynec. & Obst., February 1941.

cators of the process of encapsulation. A low lymphocytic pleocytosis should indicate a chronic abscess which is well encapsulated or relatively well encapsulated. That it does not always do so is explained by the fact that the limiting process in the meningeal reaction tends also to seal off the reaction and to prevent the appearance of cells in the spinal fluid. The localized meningeal reaction, therefore, may be sealed off without resulting pleocytosis or with fewer cells than might be anticipated by the activity of the process. A polymorphonuclear pleocytosis, on the other hand, indicates an acute abscess which is not yet encapsulated.

111 North Forty-Ninth Street.
1025 Walnut Street.

DISCUSSION

Dr. Sherman F. Gilpin Jr., Philadelphia: I should like to ask Dr. Alpers a question. Dr. Woltman and Dr. Adson observed that one can tell something about the encapsulation of an abscess from the cell count of the spinal fluid. Early it was predominantly polymorphonuclear and later it was lymphocytic, and they used the dominance of lymphocytes as one of their criteria as to when an abscess should be opened. They also related the time of surgical intervention to the point at which there was no further increase in choking of the optic disks.

I wonder whether there was any similar observation in this series.

Dr. Francis C. Grant, Philadelphia: I gathered from what Dr. Alpers said that there is a definite relationship between the chronicity of the abscess and the change in the cell content of the spinal fluid from polymorphonuclear leukocytes to lymphocytes. This, of course, is what is seen clinically and is one of the criteria on which the encapsulation of the abscess is determined. One of the more important indications for a surgical attack on an abscess is the certainty that the abscess has become encapsulated.

I should like to ask Dr. Alpers whether the abscesses he studied were produced artificially in animals or whether they were abscesses in the human brain.

Dr. Bernard J. Alpers, Philadelphia: They were abscesses of the human brain.

Dr. Francis C. Grant, Philadelphia: What was the type of these abscesses; were they hematogenous, or were they adjacent to a focus of infection?

Dr. Bernard J. Alpers, Philadelphia: Some of them were hematogenous, and some arose from extension of infections of the sinuses and mastoid. I cannot give the percentages, because we did not analyze the series in that way.

Dr. Francis C. Grant, Philadelphia: I should like to find out, further, how many of the abscesses were attacked surgically, and whether the operative and the pathologic observations were in agreement with respect to encapsulation.

Dr. Bernard J. Alpers, Philadelphia: Some of the abscesses were operated on, but I cannot say whether the operative and the pathologic observations were in agreement.

Dr. Francis C. Grant, Philadelphia: Another thing which interested me in this paper was the fact that the stage of meningeal reaction kept pace with the change in the type of cells found in the spinal fluid. I was further interested in the meningeal reaction over the adjacent sulcus or gyrus. Apparently, this meningeal reaction is always on that surface of the brain which lies closest to the

capsule of the abscess. I was also interested to see how closely the apparent time of onset of the abscess could be stated and its development traced throughout its course.

DR. H. T. WYCIS, Philadelphia: I should like to ask Dr. Alpers whether there is any relationship between the degree of encapsulation and the type of organism or infection.

DR. JOSEPH C. YASKIN, Philadelphia: I believe that in evaluating the meningeal reaction one must bear in mind the fact that the majority of cerebral abscesses are not hematogenous but arise from infections of the temporal bone and the paranasal sinuses. The infection usually traverses the meninges, often forming an epidural or a subdural abscess before invading the brain substance. It is, therefore, not surprising that meningeal irritation is common in cerebral abscesses of this type.

DR. ROBERT A. GROFF, Philadelphia: I should like to reemphasize a point to which Dr. Grant has already called attention. The presence of a definite meningeal reaction in the nature of an occlusion of the subarachnoid pathways over the abscess explains why meningitis rarely develops as the result of tapping the abscess. the surgeon can tap such an abscess without the thought of producing meningitis.

DR. FRANCIS M. FORSTER, Philadelphia: In reply to Dr. Yaskin's question as to how many of the abscesses of the brain in this series developed by direct spread, I should say that less than one-half arose in this way. The rest were metastatic and secondary to such processes as bronchiectasis and osteomyelitis of the femur.

DR. BERNARD J. ALPERS, Philadelphia: With regard to Dr. Gilpin's question, we were interested in working out this correlation, partly on the basis of Dr. Woltman's work. Dr. Woltman's study was entirely clinical, and we hoped that we should be able to correlate by means of histologic studies what he had demonstrated by clinical means. Our study appears to indicate that Dr. Woltman's observations are true; that there is a correlation between the cell count and the process of encapsulation of the abscess, so that early in the reaction the polymorphonuclear cells predominate and later lymphocytes appear. As the process becomes more chronic, the cell count falls off altogether.

With regard to determining the age of the abscess, we do the best we can. We attempt to date the abscess from the onset of symptoms.

We made no correlation between the encapsulation and the organism. That is a point on which we have no data at all, and it is an extremely important point. We made no bacterial studies. I assume that these meningeal reactions are aseptic and that there are no bacteria.

In response to Dr. Yaskin's question, it is true that abscesses develop adjacent to the mastoid and the sinuses, but it does not necessarily follow that it is by direct contiguity. An abscess may develop in the temporal lobe, without direct extension across the meninges, through thrombophlebitis, which produces relatively little reaction in itself. I do not think that one has to assume a direct extension of the abscess from the mastoid or sinus in order to explain the meningeal reaction. However, I should agree that the possibility exists.

MEASUREMENTS OF PAIN SENSITIVITY IN PATIENTS WITH PSYCHONEUROSIS

WILLIAM P. CHAPMAN, M.D.

JACOB E. FINESINGER, M.D.

CHESTER M. JONES, M.D.

AND

STANLEY COBB, M.D.

With the assistance of George Chesley, M.D., and Benjamin L. Landing, A.B.

BOSTON

THE COMPLAINT of pain has a high incidence in the civilian psychoneuroses, as well as in combat neuroses.[1] It occurs in cases of hysteria and anxiety neurosis as precise descriptions of headache, thoracic pain, cardiac pain and abdominal pain. In cases of hypochondriasis it is described in vaguer terms. It is one of the most difficult symptoms to evaluate and to treat. The problem arises as to whether in psychoneurotic persons one is dealing with thresholds of perception which differ from the normal or with different capacities toward reaction or elaboration of stimuli perceived with equal intensity by the normal person. The purpose of this study is to investigate the threshold of perception and reaction in a series of psychoneurotic patients and in a series of normal control subjects, in an experimental situation.

The Wolff-Hardy apparatus offers an instrument which can be readily used in the investigation of this problem. Values for the perception of pain and its variations have been reported in studies on a large series of normal subjects.[2] In addition, data are available on the effect of morphine,[3] nitrous oxide[4] and monoacetylmorphine[5] on the pain

The study was supported by a grant from the Josiah Macy Jr. Foundation, New York.

From the Department of Medicine of the Massachusetts General Hospital; the Massachusetts General Hospital branch of the Hall-Mercer Hospital, and the Departments of Medicine, and Neurology and Psychiatry of the Harvard Medical School.

1. Schwab, R. S.; Finesinger, J. E., and Brazier, M. A. B.: Psychoneuroses Precipitated by Combat, U. S. Nav. M. Bull. **42**:535, 1944.

2. (*a*) Schumacher, G. A.; Goodell, H.; Hardy, J. D., and Wolff, H. G.: Uniformity of the Pain Threshold in Man, Science **92**:110, 1940. (*b*) Chapman, W. P., and Jones; C. M.: Variations in Cutaneous and Visceral Pain Sensitivity in Normal Subjects, J. Clin. Investigation **23**:81, 1944.

(Footnotes continued on next page)

threshold; the effects of suggestion have also been reported.[6] These studies have been concerned essentially with the perception of pain. The present study, of which a preliminary report has been made,[7] is an attempt to compare a series of 50 patients with various psychoneuroses and 56 normal control subjects with respect to level of perception of pain and of motor reaction to pain. The threshold of perception was determined by measuring the amount of heat in gram calories required to produce a specific subjective sensation or an end point of pain. The reaction value was the amount of heat in gram calories required to produce a motor withdrawal from the source of the pain stimulus.

MATERIAL

The series of psychoneurotic patients consisted of 50 subjects, 15 males and 35 females, who were treated in the psychiatric ward of the Massachuetts General Hospital. The ages ranged from 18 to 45. The group included 22 patients with a disorder diagnosed as anxiety neurosis, 18 patients with hysteria and 10 patients with a reactive depression. The diagnoses for these patients were made in the ward, and they had no other medical or surgical disease. The series of normal control subjects consisted of 56 subjects, 15 males and 41 females. The ages ranged from 18 to 45. The control subjects represented essentially the same economic, occupational, age and ethnic groups as did the patients. It was appreciated that in the selection of any large group of normal persons there is apt to be a small percentage of people with various psychoneurotic symptoms that go undetected. An attempt was made to keep that number at a minimum by means of routine physical examination and taking of medical and psychiatric histories.

METHOD

The method and technic of these pain tests have been described more fully elsewhere.[2b] In brief, the stimulus was a painful degree of heat applied to the forehead by the Hardy pain apparatus. The source of the stimulus was a 1,000 watt Mazda lamp with a light focused by two planoconvex lenses through an aperture 2.5 sq. cm. in area. The time interval of the stimulus was kept

3. Hardy, J. D.; Wolff, H. G., and Goodell, H.: Studies on Pain: A New Method for Measuring Pain Threshold; Observations on Spatial Summation of Pain, J. Clin. Investigation **19**:649, 1940; Studies on Pain: Measurement of the Effect of Morphine, Codeine, and Other Opiates on the Pain Threshold and an Analysis of Their Relation to the Pain Experience, ibid. **19**:659, 1940.

4. Chapman, W. P.; Arrowood, J. G., and Beecher, H. K.: The Analgesic Effects of Low Concentrations of Nitrous Oxide Compared in Man with Morphine Sulfate, J. Clin. Investigation **22**:871, 1943.

5. Jones, C. M., and Chapman, W. P.: Comparative Study of Analgesic Effect of Morphine Sulfate and Monoacetylmorphine, Arch. Int. Med. **73**:322 (April) 1944.

6. Wolff, H. G., and Goodell, H.: The Relation of Attitude and Suggestion to the Perception of and Reaction to Pain, A. Research Nerv. & Ment. Dis., Proc. (1942) **23**:434, 1943.

7. Chapman, W. P.: Measurements of Pain Sensitivity in Normal Control Subjects and in Psychoneurotic Patients, Psychosom. Med. **6**:252, 1944.

constant at three seconds by a shutter operated by a telechron motor, and the intensity was varied uniformly by means of a wire rheostat. The amount of heat used was measured directly by a radiometer and potentiometer and expressed in absolute end point values of gram calories per second per square centimeter of skin surface. In order to promote the complete absorption of wavelengths, the forehead was first blackened with india ink. The pain perception threshold was taken to be the lowest stimulus necessary to cause a beginning sharp, jabbing or pricking sensation. The pain reaction threshold was the lowest average heat stimulus which caused the subject to wince. This wincing was noted as a beginning contraction of the muscles at the outer canthus of the eye. In addition, a number of the patients showed motor reactivity not only in wincing but in drawing their heads away from the stimulus.

The conditions under which these two end points were measured were standardized in the following manner. Slightly more than half the normal control subjects and the patients were tested by the same observer. To eliminate any variation in the results due to the examiner, the remaining tests on the patients and the normal controls were made by two other observers. Most of the subjects were tested on at least three different test days, each individual test consisting of from ten to fourteen exposures to a series of increasing stimuli, with a two minute interval between each two exposures. The descriptions of the varying sensations were elicited by five neutral questions asked after each exposure. These questions were:

1. What did you feel?

2. How would you describe what you felt when the stimulus was most intense?

3. Was this stimulus as intense as, or less or more intense than, the previous one?

4. Was the sensation you felt then like any you have felt anywhere on your body before?

5. [A card with seven numbered circles, varying in size from a half-dollar to a pencil point, was held before the subject.] Which circle corresponds to the size of the spot on your forehead where the stimulus seemed most intense? [It is characteristic of the stimulus that as it reaches the sharp, piercing end point it seems to focus down to nearly the size of a pencil point.]

The second test was modified in that the subject was asked to keep his head at the aperture until instructed to move it away and also in that he was told how the varying sensations are commonly described. The subject was told, "We are going to tell you how the stimulus is commonly described. At the beginning it feels like a warm glow of heat; as it becomes more intense it feels like a hot or burning sensation. Eventually the sensation changes abruptly from a burn into a sharp, jabbing or pricking sensation, about the size of a pencil point." This modification of technic was made to see whether asking the subject to keep his head at the aperture made any difference in the amount of stimulus causing him to wince and whether he continued to report the same end point value for pain perception after having the various sensations described to him, as he had with the neutral question technic alone.

At the end of each test notations were made as to any possible modifying factors, such as fatigue, nervous tension or apprehension. Inquiry was also made as to the taking of any drugs and the number of hours of sleep. When the tests were completed, "pain" was mentioned for the first time. The subject was asked to define pain and to state whether the initial sharp, piercing end point seemed to him like a beginning pain sensation.

RESULTS

The threshold values for pain perception were essentially the same for psychoneurotic patients and for comparable normal control subjects. Significant differences were observed for the threshold values for motor reaction to pain. As shown in figure 1, the mean value for the pain perception threshold in the patients was 0.288 gram calory per second per square centimeter of skin surface, with a variation of —33 to +30 per cent for the patients, as compared with 0.283 gram calory per second per square centimeter, with a variation of —19 to +33 per cent for the normal control subjects. The mean individual variation for the normal subjects was 0.011 gram calory per second per square centimeter

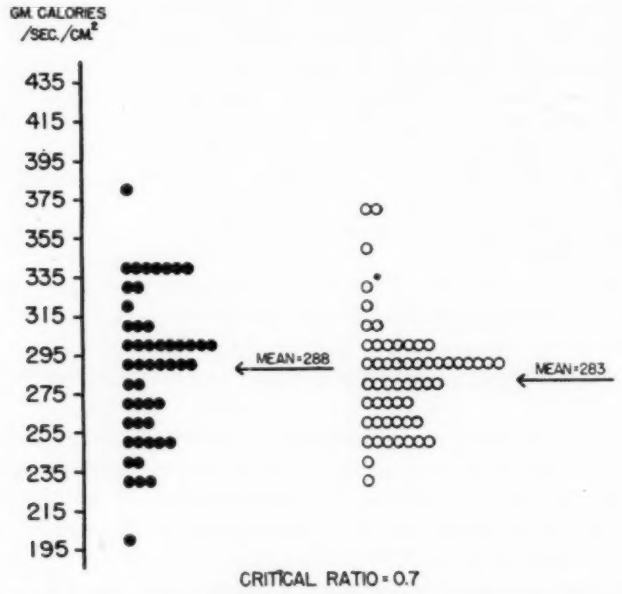


Fig. 1.—Distribution of values for perception of pain in 50 psychoneurotic patients (black circles) and 56 normal control subjects (clear circles).

of skin surface, whereas for the patients the mean individual variation was 0.013 gram calory per second per square centimeter of skin surface.[8] The mean value, however, for the pain reaction threshold (fig. 2), i. e., the point at which the subjects were found to wince or to show beginning motor withdrawal from the stimulus, was 0.314 gram calory per second per square centimeter of skin surface for the patients, as

8. The lowest value for perception or reaction at which the subject reacted at least on one occasion on a test day (the lowest inconsistent value) was subtracted from the lowest value at which the subject reacted to all exposures on the same test day (lowest consistent value). The average of these differences was calculated for the patients and for the control subjects and is referred to as the mean individual variation.

compared with 0.347 gram calory per second per square centimeter for the normal control subjects. The difference between these mean values is significant, the critical ratio being —3.9. The mean individual variation in reaction was 0.019 gram calory per second per square centimeter for the patients and 0.011 gram calory per second per square centimeter for the controls, or nearly twice as much for the patients as for the control subjects.

For various reasons, data were not available for the three successive test days for all the patients and for all the control subjects. The data on which figures 1 to 4 were constructed are the summary values

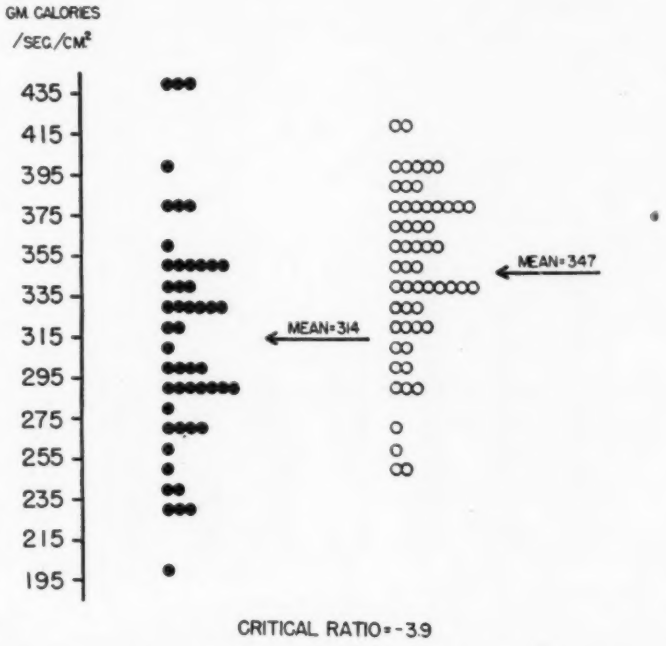


Fig. 2.—Distribution of values for motor reaction to pain in 50 psychoneurotic patients (black circles) and 56 normal control subjects (clear circles).

for perception and reaction. These were obtained by averaging the mean values for three test days whenever this was possible. For 21 patients and for 17 control subjects the summary values were obtained by averaging the mean values for two test days. For 13 patients and for 6 control subjects the summary value is the mean for only one test day.

Distribution frequency curves for the perception and the reaction values for patients and for control subjects are presented in figures 1 and 2. The perception values for the normal controls seem to follow a normal distribution curve, with the mean at 0.288 gram calory per second per square centimeter. The patients show a slightly greater

range, and the distribution tends toward a bimodal type of curve. In the distribution of values for pain reaction, the patients again show a slightly greater range than the controls; both curves tend to show a bimodal distribution. It can be seen (fig. 2) that the values for the control subjects tend to be greater than those for the patients.

Data are presented on the difference between the perception level and the reaction level for both patients and controls. In figure 3 these differences are expressed in absolute values. It can be seen that 20 per cent of the patients and about 4 per cent of the control subjects showed a motor reaction at a stimulus value below that at which they perceived pain. These are shown in the column listed as "differences less

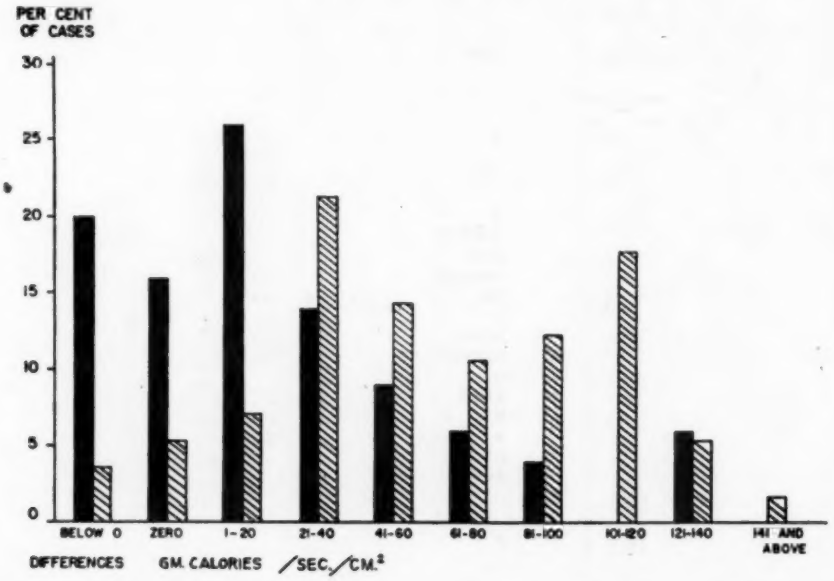


Fig. 3.—Difference between values for perception of and motor reaction to pain in 50 psychoneurotic patients (black areas) and 56 control subjects (cross hatched areas). The values along the abscissa are expressed in terms of gram calories per second per square centimeter of skin surface.

than zero." Seventeen per cent of the patients and 6 per cent of the control subjects had both perception and motor reactions at the same stimulus level. A difference of 1 to 20 points between the perception and the motor reaction level is seen for 26 per cent of the patients and for 7.1 per cent of the normal control subjects. As the difference between the perception levels and the reaction levels become increasingly greater, there are found relatively more control subjects than patients. In figure 4 the same data are presented as per cent differences between perception and reaction levels. Essentially the same trend and the same distribution for patients and for controls are seen.

The foregoing data show a significant difference between the patients and the control subjects in respect to the amount of stimulus necessary to cause the motor reaction. It required significantly less stimulus to evoke the motor reaction in the patients than it did in the control subjects. This was not the case when the perception values for pain were measured. The differences in motor reaction between the controls and the patients are significant when the summary values are used as well as when the values for each test are used (table 1). The critical ratios are significant for all comparisons (tables 1 and 3).

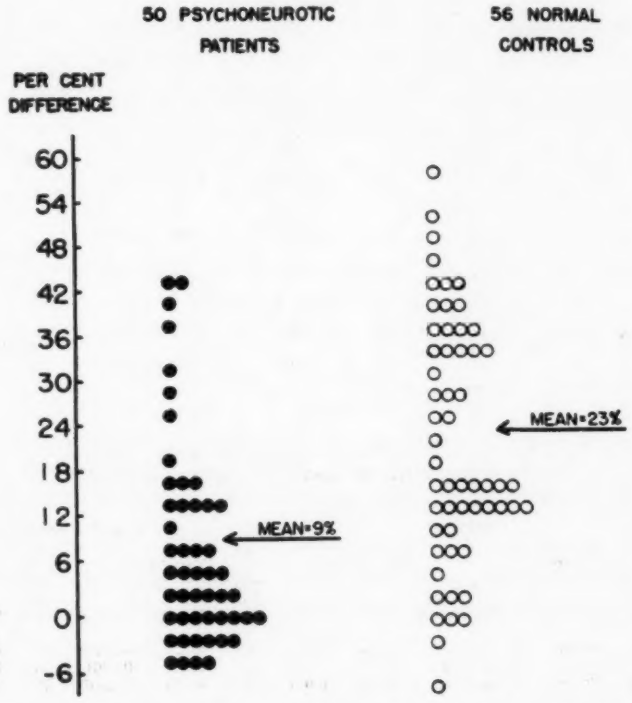


Fig. 4.—Per cent difference between values for perception of and reaction to pain for 50 psychoneurotic patients (black circles) and 56 normal control subjects (clear circles).

In addition to the difference in the wincing reaction, it was noted that a significant number of the patients showed a more pronounced motor withdrawal, to the extent of moving the head away from the aperture. Unfortunately, a consistent record of this more marked withdrawal was not kept until the investigation was well under way. When an attempt was made to elicit the complete withdrawal response, it was found that only 4 per cent of the normal control subjects moved the head away from the aperture when the stimulus had been carried to 0.300 gram calory per second per square centimeter of skin surface. For this same amount of the stimulus 38 per cent of the patients moved

their heads away. The patients therefore exhibited an increased hyperactivity to pain by showing beginning motor withdrawal at a significantly lower level of stimulus than the normal controls, and in a number of cases by showing a more marked motor withdrawal.

TABLE 1.—*Difference in Gram Calories Between Threshold Values of Motor Reactivity to Pain and of Pain Perception*

	No.	Mean	Standard Deviation	Probable Error	Critical Ratio
		Summary Value			
Controls	56	0.062	0.041 ± 0.004	0.005	7.08
Patients	50	0.027	0.038 ± 0.004		
		Values for Individual Tests			
		Test 1			
Controls	37	0.062	0.037 ± 0.004	0.006	7.58
Patients	22	0.014	0.033 ± 0.005		
		Test 2			
Controls	53	0.060	0.042 ± 0.004	0.006	6.5
Patients	42	0.024	0.037 ± 0.004		
		Test 3			
Controls	49	0.073	0.051 ± 0.005	0.007	6.9
Patients	39	0.028	0.039 ± 0.004		

TABLE 2.—*Mean Threshold Values* for Pain Perception and Motor Reactivity to Pain for Patients and for Control Subjects*

	Patients						Control Subjects					
	Perception			Reaction			Perception			Reaction		
Tests	No. Cases	Mean	S. D.	No. Cases	Mean	S. D.	No. Cases	Mean	S. D.	No. Cases	Mean	S. D.
1	22	0.282	0.036	22	0.296	0.041	37	0.277	0.0272	37	0.341	0.0452
2	42	0.291	0.039	42	0.315	0.053	53	0.281	0.0261	53	0.342	0.0449
3	39	0.278	0.036	39	0.306	0.054	49	0.285	0.0316	49	0.358	0.0492
Summary values	50	0.287	0.0364	50	0.314	0.054	56	0.283	0.0278	56	0.347	0.041

* Values for thresholds are expressed in gram calories per second per square centimeter of skin surface.

TABLE 3.—*Statistical Significance of Threshold Values for Perception of and Reaction to Pain for Patients and for Controls*

	Controls	Patients
Critical ratio between perception and reaction, test 1	—11.0	—1.7
Critical ratio between perception and reaction, test 2	—12.8	—3.5
Critical ratio between perception and reaction, test 3	—12.9	—3.9
Critical ratio of difference between perception, tests 1, 2 and 3 and reaction tests 1, 2 and 3	—14.0	—4.1
	Controls and Patients	
Critical ratio of difference between summary values of perception of pain	+0.70	
Critical ratio of difference between summary values of reaction to pain	—3.85	

As regards differences in pain reactivity in the various groups of psychoneurotic patients, there was a tendency for the patients with anxiety neurosis and hysteria to wince with a smaller stimulus than for the patients with hypochondriasis. While these differences are suggestive, this series of cases is too small for one to say definitely that different types of psychoneurotic patients can be distinguished in terms of their reactivity to cutaneous pain.

The foregoing results showed that whereas the patients responded by motor reaction to less stimulation than did the control subjects, this was not true for the perception of pain. We felt that it would be of interest to determine whether the threshold for motor response would increase on repeated tests. A small series of 11 patients were tested on six successive test days. The mean values for each test day in the entire series remained unchanged both for perception and for motor reaction. Repeated testing did not change the threshold values in this series of patients.

COMMENT

These studies demonstrate that psychoneurotic patients require essentially the same amount of stimulus to perceive cutaneous pain as do normal control subjects. The patients differ from the control subjects in that it requires significantly less stimulation to cause a motor withdrawal reaction. It would have been of interest to know whether this hyperactivity was expressed in other ways, such as changes in pulse, blood pressure and respiratory rate. Such data were not obtained, as we wished to avoid unduly complicating the experiment. Such information would be of interest because of the known autonomic instability in certain psychoneurotic patients. When adequate base lines for autonomic activity are established, the effects of pain on these functions will be of interest. For such studies it will be necessary, however, to use a painful stimulus which is maintained for a longer interval than three seconds.

A number of variables are encountered in a study of this nature. They have been discussed at length in another communication [2b] and may be enumerated here by the following questions:

1. Is the stimulus used a measurable one?
2. Is the stimulus applied to that portion of the body where the neurohistologic variations are at a minimum?
3. Does the stimulus produce a readily appreciated end point of pain?
4. Is proper consideration given to factors which at the time of the test may influence the level of pain sensitivity?
5. Is the proper question technic used to elicit an adequate description of the stimulus?

In the present study these criteria were met by the technic previously described. A point which may be raised regarding this investigation involves the question whether a subject evaluates the sharp, jabbing end point as pain. At the completion of the test the normal control subjects and the patients were asked to define pain. It is noteworthy that 80 per cent of the subjects, in answer to this question, volunteered that pain was something that hurt, and that the beginning sharp, jabbing sensation experienced from the heat was considered painful because of its hurting quality. On the first test day the patients were not told what to expect and were not given any description of the nature of the stimulus or of the reaction. On the second test day, however, they were told what to expect, as previously described. The main values for perception and reaction were essentially the same in test 1 and test 2. This would indicate that the end results were the same whether or not the subject was given a description of the sensation caused by the stimulus.

The results of these experiments on sensitivity and reaction to pain are in keeping with other observations on the reactivity of psychoneurotic patients. During basal conditions, while extraneous stimuli are at a minimum, psychoneurotic patients have significantly greater irregularities in the respiratory pattern [9] than do schizophrenic patients and normal control subjects. Previous studies have shown that patients with hysteria, anxiety neurosis, phobia and reactive depression show greater reactivity in ventilation, rate of respiration, spirographic irregularities, heart rate and muscular tension in response to ideational, auditory and painful stimuli than do normal control subjects.[10] These experiments indicate that cutaneous pain as elicited by exposure to heat is another form of stimulus to which psychoneurotic patients respond as hyperreactors.

The fact that in these patients the stimulus for the perception of pain was essentially the same as that for the control subjects would indicate that the afferent pathways mediating the painful stimulus function normally in psychoneurotic patients. The explanation for the greater reaction is at present unknown. However, some light on

9. Finesinger, J. E.: The Spirogram in Certain Psychiatric Disorders, Am. J. Psychiat. **100**:159, 1943.

10. Finesinger, J. E.: The Effect of Pleasant and Unpleasant Ideas upon the Respiration in Psychoneurotic Patients, Arch. Neurol. & Psychiat. **42**:425 (Sept.) 1939. Finesinger, J. E., and Mazick, S. G.: The Effect of a Painful Stimulus and Its Recall upon Respiration in Psychoneurotic Patients, Psychosom. Med. **2**:333, 1940. Finesinger, J. E.: The Effect of Pleasant and Unpleasant Ideas on the Respiratory Pattern (Spirogram) in Psychoneurotic Patients, Am. J. Psychiat. **100**:659, 1944.

the problem is thrown by a similar study,[11] in which it was found that patients whose chief complaint was nervousness showed a lower threshold of reactivity, i. e., greater reaction, than did a similar group of patients whose major complaint was thoracic pain. The perception values for the two groups were essentially the same. This would suggest that the greater reactivity is associated principally with complaints of nervousness in patients in whom this is the chief complaint.

SUMMARY

Measurements on the threshold of perception of pain and the motor reaction to pain were made on a series of 50 psychoneurotic patients and on a series of 56 normal control subjects.

The values for the threshold of perception of pain were essentially the same for the patients and for the control subjects.

The threshold values for the motor reaction to pain were significantly greater for the control subjects than for the patients. A much smaller stimulus was required to evoke a motor response in the patients than in the control subjects.

The evidence indicates that psychoneurotic patients tend to show a greater motor reactivity to a painful stimulus than do normal control subjects.

Massachusetts General Hospital.

11. Chapman, W. P.; Cohen, M. E.; Cobb, S., and White, P. D.: Measurements Related to Pain in Neurocirculatory Asthenia, Combat Fatigue, and Anxiety Neurosis, J. Clin. Investigation **25**:890 (Nov.) 1946.

INCIDENCE OF COMBAT FATIGUE

COMMANDER PHILIP SOLOMON (MC), U.S.N.R.

IN SPITE of the many papers on combat fatigue which have appeared in the literature since the onset of World War II, there have been few, if any, controlled studies on the incidence of the disorder. My experience as division psychiatrist with a Marine division before, during and after the Okinawa campaign offered an unusual opportunity for the observation of combat fatigue in all stages and for the gathering of appropriate related data. The present paper will present the collected material regarding the incidence of combat fatigue with respect to (1) the individual, (2) the group and (3) the type of warfare.

THE INDIVIDUAL

The following data were obtained from 627 patients with combat fatigue and from a control group of 205 Marines. The patients were seen in the division field hospital, usually within a few hours after they broke down. The control group, taken from the same regiments, were studied after the operation was over. The data were corrected for the time interval. All differences are statistically significant, each difference being three or more times as large as the standard error of the difference.

Age.—The patients with combat fatigue were younger than the controls. The mean age was 21.6 years, as against 23.3 years. Since the older men were exposed to the same hazards as the younger men and were not given favored jobs, it would seem that the greater maturity associated with the older age made for greater stability and resistance to combat fatigue.

Marital Status.—There were more married men among the controls than among the patients with combat fatigue (32 versus 22 per cent). This may be a reflection of the greater age or may be another indication of greater maturity.

Education.—The controls had gone further in school. The means of the highest grade attained was 11, as against 10 for the patients. This difference may be due in part to more younger men among the combat fatigue group having had their education interrupted by the war, or, again, it may be an indication of greater maturity and stability of the

---

This article has been released for publication by the Division of Publications of the Bureau of Medicine and Surgery of the United States Navy. The opinions and views set forth in this article are those of the writer and are not to be considered as reflecting the policies of the Navy Department.

controls. It will be noted that both groups showed a high level of educational attainment. This is largely due to the fact that the Marines selected for this division were carefully chosen and were minutely screened by training before they entered combat.

Place in the Family.—During the work with the patients with combat fatigue, I was impressed with the seemingly large number of men who were the youngest members of their families. On statistical analysis, however, it developed that the group with combat fatigue and the control group were essentially alike in this respect and that in each the distribution with regard to the position among the siblings was a normal one. This negative finding is mentioned as an interesting illustration of the fallibility of clinical impressions.

Service Life.—The two groups differed slightly in their length of active duty in the service. The mean for the combat fatigue group was twenty-five months, whereas for the controls it was twenty-eight months. However, though they had been on active duty a little less, the combat fatigue group had been overseas a little longer (fourteen months, as against twelve months). They had also seen more action. For only 56 per cent of them was Okinawa their first campaign; for 24 per cent it was their second, and for 20 per cent, their third or fourth. Of the controls, Okinawa was the first campaign for 78 per cent, the second for 10 per cent and the third or fourth for 12 per cent. These findings indicate that the combat fatigue group had been exposed to greater stress in the service.

THE GROUP

During the entire Okinawa operation, which lasted for eighty-two days, 627 patients with combat fatigue were seen at the division field hospital, and an additional 209 were evacuated directly to rear area hospitals. The total of 836 patients constitutes approximately 6 per cent of the total casualties and 3 per cent of the total strength of the division. These figures are far lower than those usually encountered in combat, and they compare most favorably with those of other divisions that took part in the Okinawa operation. In explanation, the following points may be noted:

1. Preventive measures were instituted before the division went into combat. These have been described in a previous paper.[1] Particularly effective were the excellent state of the mental health of the troops, the indoctrination in psychiatric matters of the line officers and the medical officers and the practice of establishing rest camps under line control within the individual combat battalions and regiments.

1. Solomon, P.: Psychiatric Preparations for Combat in a Marine Corps Division, U. S. Nav. M. Bull. **45**:310-313 (Aug.) 1945.

2. The morale of the division was especially high throughout the operation, in part because of its unusual success in carrying out its objectives against the enemy. With the exception of one brief period (at Sugar Loaf Hill, to be discussed later), the division was in constant victorious forward motion.

3. The diagnosis of combat fatigue was scrupulously confined to its proper definition of neurotic breakdown in essentially normal persons under the stress of combat.[2] Cases of blast concussion, exhaustion due to overexertion, heat exhaustion, operational fatigue, preexisting psychoneurosis, personality disorder, reactive depression, manic-depressive disorder and combat psychosis were excluded.

Nearly all the cases of combat fatigue occurred in the infantry regiments. These will be designated as regiments A, B and C. Together, their total strength made up little more than one-half the strength of the division. In the Okinawa operation, the three regiments were exposed to approximately equal durations and intensities of combat. Yet regiment A, which suffered the most deaths and men wounded in action, had by far the least combat fatigue; regiment B, which had the least deaths and the least wounded in action, had the most combat fatigue; regiment C was between in all categories. These discrepancies were found to correlate in interesting fashion with certain characteristics of the individual regiments.

Regiment A had 148 men with combat fatigue, 2,130 wounded in action, 510 deaths and 3,700 total casualties The ratio of men with combat fatigue to the total casualties was 4.0 per cent, and to the total battle casualties, 5.6 per cent. Regiment A was an old, famous Marine regiment. Its leader was an equally famous colonel, whose leadership and personality characteristics were such that the loyalty of his officers and men toward him can be described only as phenomenal. The medical officers had ample opportunity to witness this fact. The men ignored minor wounds, and it was only with difficulty that some of the more seriously wounded could be kept in the field hospital. "They need me up there," was heard again and again. Evidences of intrepidity, pal spirit and pride in their accomplishments were frequent. Though this paper is concerned only with the incidence of combat fatigue, it may be noted that regiment A, with the lowest incidence of combat fatigue, had the highest rate of return to duty for patients with combat fatigue and the lowest rate of recurrence. There can be little question that these facts are a result of the astoundingly high level of the morale of the men.

---

2. Solomon, P.: The Diagnosis of Combat Fatigue, U. S. Nav. M. Bull., to be published.

Regiment B had 442 men with combat fatigue, 1,780 wounded in action, 420 deaths and 3,950 total casualties. The ratio of men with combat fatigue to the total casualties was 11.2 per cent and to the total battle casualties, 20.0 per cent. Regiment B was also an old well known Marine regiment, but there was prevalent in it a definite feeling of bitterness and pessimism. The men felt that they had not received adequate recognition for their earlier accomplishments in the war. Their combat efficiency had been extremely high, and they were noted for their meticulous care in planning and well oiled coordination in action.

In regiment B, the division slogan of "Hold high the torch!" was little heard. Instead, the men frequently cried, "Ram high the rod!" or "Hold those baskets higher!" or "See those little purple hearts pinned around the basket!" [3] The colonel was an extremely capable man and highly revered. A story was passed around, however, to the effect that the colonel was convinced he was going to "get his" in his third operation, and this was his third operation. The story was no doubt unfounded,[4] but its acceptance among the men was another indication of the low spirit that prevailed.

In spite of the sardonic pessimism, regiment B turned in a uniformly good performance until the assault began on the Naha-Shuri line. At this time heavy rains turned the battlefield into a sea of mud. The movement of mechanized vehicles was almost impossible. The enemy stood fast and resorted to a heavy concentration of mortar and artillery fire. Each day morale in the regiment sank lower and lower. As casualties mounted and replacements did not arrive, it became generally felt in the regiment that their mission was hopeless. Line officers, medical officers, corpsmen and riflemen all joined in defeatism. The culmination of this occurred at Sugar Loaf Hill, a name that will go down in Marine Corps history. This position changed hands eleven times, but for days it could not be held. Patients with combat fatigue now began turning in in large numbers. "I can't take it, Doc," they would say. For three days there were over a hundred such patients a day. In some decimated companies which were down to 30 or 40 men, the entire group was turned in in a body. Finally, drastic steps were taken to put a stop to this. A modification of assignment and changes in personnel were made. Medical officers, as well as line officers, were switched about. The division psychiatrist visited the regiment daily. Finally, the weather cleared; replacements of men arrived; the enemy line was broken, and the crisis was passed.

---

3. Gruesome humor referring to "basket cases," in which all four limbs are amputated. All three slogans have a masochistic coloring.

4. It was also not prophetic, though the colonel's successor in command of the regiment was killed at Okinawa.

Regiment C had 240 men with combat fatigue, 1,900 wounded in action, 490 deaths and 3,375 total casualties. The ratio of men with combat fatigue to the total casualties was 7.1 per cent, and to the total battle casualties, 10.0 per cent. Regiment C was made up largely of men recently drafted. The colonel was generally regarded as an excellent man, but there were many who felt he was still fighting the Nicaraguan campaign. He had overtrained his men until they had "gone stale." There was a great deal of carping criticism down through the level of the officers to the men. In maneuvers they rated low efficiency marks resulting in even more strenuous training; yet blunders continued. The officers and men were tired, disgruntled and convinced they were "a hard luck outfit."

In the third week at Okinawa, regiment C again manifested inefficiency. A few ambushes by the enemy and light casualties seemed to stymie them. They were convinced they could not take their assigned objective. Regiment A replaced them and took the enemy position in a breeze, accepting their heavier casualties with apparent disdain. Later in the operation, regiment C, with a new commanding officer, seemed to pull itself together and turned in a sterling performance.

TYPE OF WARFARE

Those who have never been in combat are inclined to think of it as a rather uniform matter: A man is either in combat or he is not. Nothing could be further from the truth. At Okinawa, as in other military operations, whole divisions were sent into "combat." Actually, less than 40 per cent of the personnel of an assault division did the fighting. The remaining 60 per cent or more were never exposed to sufficient stress or strain to produce combat fatigue. Even those who did take part in the actual fighting varied widely in the intensity and duration of their experiences. In the following paragraphs I shall attempt to evaluate the efficacy of the different military phases at Okinawa in the production of combat fatigue.

The Landing.—At Okinawa, the Marines hit their first "cold" beach in World War II. There were practically no casualties of any sort, and of course no combat fatigue. The tension of anticipation, in the normal man, changes rapidly to profound relief and high spirits when no opposition is encountered in the initial assault at the target. In other operations, such as those at Tarawa and Iwo, where the beach was "hot," the emotional strain was extreme, and many cases of combat fatigue resulted in a short time in spite of little physiologic depletion in the men.

Rapid Advance in Northern Okinawa.—The division with which I was privileged to serve advanced rapidly for the first two weeks of the

operation. Enemy resistance was light and scattered. Only the forward patrols saw any real action. There were few casualties and only an occasional case of combat fatigue. Optimism ran high among the men.

The Motobu Peninsula.—A determined enemy in strength was first encountered in the third week, on the Motobu Peninsula. As previously noted, regiment C here ran into difficulty. Two companies were ambushed by the enemy and exposed to heavy machine gun and Nambu fire. There were many casualties, and some of the men who were pinned down could not be rescued for hours. Some 30 cases of combat fatigue resulted, but it was not severe and all the men returned to duty in a few days.

The Resting Stage.—Northern Okinawa was declared secure at the end of the third week. For the next two weeks the division remained relatively inactive. There was constant patrolling, but only scattered sniper fire was met. There were a few enemy air raids, but bombing was light and inaccurate, doing no damage. The chief anxiety during this period concerned the future. There were rumors that the division would make another major landing nearer the enemy homeland. Several men felt that they could not stand another operation and turned in with symptoms of operational fatigue, but there was no combat fatigue.

The Naha-Shuri Line.—At the end of the fifth week the division was relieved by occupation troops and moved south to take over a sector of the line which the enemy was holding in determined fashion against the Army. Heavy fighting of an entirely different sort now began. Progress, as judged by the accomplishments in Northern Okinawa, was extremely slow. Enemy mortar and artillery fire was continuous and often of deadly accuracy. The Marines, who respect good marksmanship, claimed the Japs could drop a knee mortar in a man's pocket at a thousand yards.

As battle casualties mounted to 200 or more a day, combat fatigue became a major problem. Lagging a day or two behind the rise in battle casualties, cases of combat fatigue rose steadily from 20 to 40 or 60 a day. Finally, at the end of a week of this grueling fighting—with constant rain and mud; inadequate food, water, shelter and rest, and under incessant shelling—the nerves of some of the hardiest could take no more. Morale in regiment B, which was unsuccessfully attempting to take Sugar Loaf Hill, slumped, and the influx of over 100 cases of combat fatigue a day took place, as has already been described. Many of the men who were brought in at this time were battle-hardened veterans, some in their third or fourth operation. They confessed frankly that they had never seen anything like this before and that they could take it no longer. "If we could only see somebody to shoot at and fight back at, it wouldn't be so bad," they said. These men

showed marked physical depletion. They were haggard, covered with mud and usually sat staring fixedly at the ground with glazed eyes. If a shell fell in the hospital area, they "hit the deck" with the rest; but often they remained there trembling and moaning, unwilling to get up. Some of them reacted with a marked startle response to the noise of their own guns.

With the cracking of the Naha-Shuri line and the capture of Naha, the incidence of combat fatigue rapidly dropped off. Battle casualties continued heavy for another week, but the weather had now improved, replacements had come in, transportation permitted more satisfactory attention to the physical needs of the men, and morale rose because of the victorious progress that had been made. At the end of the eighth week on Okinawa there were a few days of relative quiet in the division while positions were consolidated and preparations were made for the next phase of the operation.

The Orotu Peninsula.—In the tenth week, regiment A made an amphibian landing on the Orotu Peninsula, site of the enemy naval base and of the Naha airfield. Resistance during the landing was light, but the regiment took heavy casualties during the lightning-fast clean-up of the peninsula. Cases of combat fatigue were extremely few, remarkably so in proportion to the heavy battle casualties. In explanation, it may be noted that the casualties were due primarily to small arms fire, which Marines tolerate easily, and that the spirits of the men were high because of their easy landing and rapid forward movement. Besides, the end was now definitely in sight. In the eleventh week there was another relative lull before the attack was launched that carried through to the end of the island.

The Southern Tip.—In the twelfth week the Marines plunged across the southern tip of Okinawa and reached the sea. The remaining enemy forces were cut into small groups and annihilated. Again, there were many battle casualties, but combat fatigue was almost completely absent. The weather became extremely hot at this time, and a few cases were turned in as cases of combat fatigue that were really cases of heat exhaustion. Enemy resistance once more was largely small arms fire, and high spirits prevailed because the final victory was at hand. Furthermore, rumor had it that the division was to be relieved at once and taken to rejoin the rear echelon at a prepared camp in Guam.

The island was officially declared secure on the eighty-second day, but mopping up continued and the division did not embark for two or three more weeks. Combat fatigue ceased with the end of combat. After over a hundred days on Okinawa, there were no regrets at seeing the end of combat, the end of combat fatigue and the end of Okinawa.

INDIVIDUAL STRESSES

A word should be added regarding the evaluation of individual experiences in terms of production of physical and emotional stress and combat fatigue. It was remarkable how little the men seemed to be affected by exposure to the elements. After many days and nights spent in muddy foxholes under constant rain, with practically nothing available in the way of toilet facilities, no hot food, a scarcity of water, almost no chance to sleep because of the lack of shelter, noise and need for alertness, not a single man who broke down with combat fatigue had a word of complaint with respect to these matters. There could be no more convincing demonstration of the importance of a scale of relative values. In training camp and in maneuvers, these same men would set up a hue and cry in typical G. I. style at the slightest inconvenience. But in combat, life itself is at stake, and everything else in the way of physical comforts seems to drop completely out of the picture.

The same was not true in the emotional sphere. Combat demonstrates irrefutably that there are some forces even more potent in motivating behavior than self preservation. What makes a man stay in there and take it when men are being killed all around him? Probably the following reasons, which are noted in the order of their importance:

Compulsion: Fear of the consequences if he tries to get out of it. This no doubt stems from deep-seated submissiveness to authority and acceptance of the father surrogate. In the front lines it seems simply a matter of not wanting to get shot in the back or be court-martialed for "turning tail."

Loyalty: Fealty to his leaders and his buddies. Allegiance to the cause and patriotism seemed far distant. Homosexual roots were not in evidence.

Hope: The sublime faith that he will somehow come through all right. This doubtless arises from a belief in magic, but to the practical Marine it is based on such realistic matters as being relieved regularly by the rotation of troops in the front lines, the superiority of arms and equipment over those of the enemy and confidence in himself and in his leaders. This feeling fluctuates widely, depending on the military state of the operation and the fortunes of war. It rises enormously when victory is in sight.

Emotions of lesser importance, such as hatred for the enemy (sadistic tendencies are rare) and resignation to one's lot (masochistic tendencies are even rarer).

Bearing in mind these reasons that men stay in the lines, it will be easier to understand why they break down neurotically with combat fatigue and leave the lines. The simplest way to cause a large influx

of men with combat fatigue is to make it easy for them to turn in. If, during a prolonged ordeal, such as the one at Sugar Loaf Hill, the compulsion to remain is removed (by defection in command [5] or oversympathy on the part of medical officers and corpsmen), combat fatigue will spread like mass hysteria. Under ordinary combat conditions, one of the commonest precipitating factors in combat fatigue in the individual soldier is the death or maiming of one of his buddies. Combat fatigue may be a simple severe grief reaction. Many a man turns in with combat fatigue only after all his buddies are gone. "I don't know these new men," he says. He feels no loyalty toward them. Lack of confidence is a potent factor. "The new lieutenant didn't seem to know what it was all about," one patient said. "The new, green men are no good. They get themselves killed so foolishly. You can't rely on them," said another. When hope changes to despair, combat fatigue is near at hand. Combat fatigue may be the result of an unfortunate accident. When a man unknowingly kills one of his own officers or men, he usually succumbs to combat fatigue. A miraculous escape, as when a shell lands in a group, killing all the others but leaving one man unscathed, often is the harbinger of combat fatigue. "My luck has run out; I know it has," one man said. But by and large, combat fatigue is the result of the accumulation of many stresses and strains, both physical and emotional, with the leading one fear of death, to the point at which the man's threshold is reached and he cannot stand it any longer. "I couldn't take it any more, Doc," is the commonest statement made by patients with combat fatigue.

SUMMARY

A controlled study of the incidence of combat fatigue in a Marine division at Okinawa revealed the following facts:

1. The Individual: Patients with combat fatigue, as compared with controls, were younger and less well educated; fewer were married, and, though they had been in the service a little shorter time they had been overseas longer and had seen more combat. These findings presumably indicate what might have been expected, namely, that the patients with combat fatigue were less mature or less stable and were exposed to greater stress.

2. The Group: There was an unusually low incidence of combat fatigue in the division, which seemed to be due, at least in part, to preventive measures and to the high morale produced by continuous military success. The differences in incidence of combat fatigue in the three infantry regiments correlated closely with the morale factors of the separate regiments.

5. The incidence of combat fatigue in officers was 0.4 per cent, much lower than in enlisted men.

3. The type of warfare: Exposure to combat is not a uniform matter. The physical and emotional stresses that make for combat fatigue vary greatly according to the type of combat and the personal experiences of the individual soldier in combat. At Okinawa, there were wide variations in the incidence of combat fatigue at different phases of the operation. The factors which abetted the development of combat fatigue were chiefly those that affected the patient emotionally. The most potent, in addition to the fear of being killed, were those that counteracted the basic reasons that a man remains in the lines in spite of his fear of being killed. The basic reasons are considered to be compulsion, loyalty, and hope.

416 North Bedford Drive, Beverly Hills, Calif.

PARAMYOCLONUS MULTIPLEX (FRIEDREICH)

A Clinicotherapeutic Study

ARTHUR A. MORRIS, M.D.
MEMPHIS, TENN.

IN 1881 Friedreich [1] described paramyoclonus multiplex as a syndrome characterized by the occurrence of abrupt twitches in bilaterally symmetric muscle units. The twitches were asynergic and affected only distal muscle groups. During sleep the myoclonic twitches disappeared; but voluntary relaxation, and mechanical, thermal, electrical and emotional stimuli produced an increase in the frequency and degree of contractions. A conspicuous absence of signs and symptoms of disease of the peripheral and central nervous systems was observed.

Since the cause of paramyoclonus multiplex has remained obscure, numerous remedies may be found in the literature. A summary of the various forms of treatment used formally is recorded in table 1. In addition, when the disease occurs after trauma (Starr [2]), mental and physical exertion or fevers (Raymond,[3] Bing,[4] Keschner,[5] Lafforgue [6]), or as an accompaniment of lead poisoning (Leusche), dementia paralytica (Gravitz, Williams), endocrine disorder (Magaudda), neurosyphilis (Weingrow [7]), anterior poliomyelitis (Bailey), meningoencephalitis (Clarke), black widow spider bite (Kirby-Smith [8]) or

---

From the Department of Neuropsychiatry, Duke University School of Medicine, Durham, N. C.

1. Friedreich, N.: Neuropathologische Beobachtungen Paramyoclonus multiplex, Virchows Arch. f. path. Anat. **86**:421-436, 1881; translated, J. Nerv. & Ment. Dis. **30**:466, 1903.

2. Starr, A.: Paramyoclonus Multiplex, with a Report of a Case, J. Nerv. & Ment. Dis. **14**:416-427, 1887.

3. Raymond, F.: Leçons sur les maladies du système nerveux, Paris, O. Dorn, 1896, p. 550.

4. Bing, R.: Textbook of Nervous Diseases, translated and enlarged from the German by W. Haymaker, St. Louis, C. V. Mosby Company, 1939, p. 145.

5. Keschner, M., in Tice, F.: Practice of Medicine, New York, W. F. Prior Company, Inc., 1920, chap. 10, p. 418.

6. Lafforgue: Paramyoclonus d'origine ourlienne, Rev. de méd., Paris **32**: 303-306, 1912.

7. Weingrow, S. M.: Paramyoclonus Multiplex and Neurosyphilis, J. Nerv. & Ment. Dis. **85**:557-560, 1937.

8. Kirby-Smith, H. T.: Black-Widow Spider Bites, Tennessee M. J. **31**: 357-361, 1938.

TABLE 1.—*Summary of the Various Treatments Formally Used for Paramyoclonus Multiplex*

Date	Name	Treatment	Results
1881	Friedreich [1]	Liver oil	Unsuccessful
1883	Löwenfeld, L.: Aerztl. Int.-Bl. **30**: 151 and 164, 1883	Galvanization of spinal cord; galvanization of superior cervical ganglion, with addition of zinc valerianate at same time	Prompt improvement with only galvanization of the superior cervical ganglion; no lasting cures obtained
1886	Schultze: Neurol. Centralbl. **5**: 363-369, 1886	Strong central galvanization of spinal cord and application of labile galvanic current to affected muscles in Friedreich's original case	Improvement for short period but twitches returned and lasted until death, 2 yr. later
1887	Homen, E. A.: Arch. de neurol. **13**: 200-209, 1887	Galvanization of spinal cord	Unsuccessful
		Warm baths in quiet circumstances	A patient did well
1887	Bechtereff, V.: Arch. f. Psychiat. **19**: 88-103, 1887	Fowler's solution (solution of potassium arsenite U. S. P.) and zinc valerianate	Effectively treated a single patient, a mildly anemic woman whose twitches appeared following an abortion
1895	Unverricht [9]	Atropine and scopolamine	Unsuccessful
1902	Langdon, F. W.: J. Nerv. & Ment. Dis. **29**: 541-548, 1902	Scopolamine hydrobromate, 1/200 grain (0.3 mg.) every 3 hr.; potassium iodide, chloral hydrate and potassium bromide; solution of potassium arsenite U. S. P.; sulfonal (every 3 hr. for 3 days); fluidextract of Cactus grandiflorus; sodium phosphate; morphine; desiccated thyroid; sodium bromide; Conium; Squibb's fluidextract; quinine, and arsenic	None of the many remedies used singly or in combination were useful
1919	Westphal, A.: Arch. f. Psychiat. **60**: 769-782, 1919	Phenobarbital	Some improvement
1922	Roger, H.: Ann. de med., Paris **12**: 150-170, 1922	Phenobarbital	Slight improvement
1923	Ramsay, J. C.: Brit. M. J. **2**: 878, 1923	Intestinal antiseptics and full doses of methenamine (hexamine)	Had some degree of success in a sporadic case
1927	Reid, J.: Practitioner **118**: 191-194, 1927	Bilateral ovariectomy. Trial of curettage, Weil-Mitchell regimen, application of powerful electrical currents, arsenic, chloral and bromides recommended first. Author stated that perhaps ovariotomy, complete on one side and partial on the other, or unilateral vasectomy (in the male) should be tried	Woman aged 56 who had paramyoclonus multiplex for eighteen years was cured
1932	Sœuer, R.: J. de neurol. et de psychiat. **32**: 307-314, 1932	Tendon transplants and stripping operations for orthopedic relief	Success in highly selected cases
1941	Brewster, E. S.: J. Nerv. & Ment. Dis. **93**: 723-730, 1941	10 cc. of 10% calcium gluconate combined with 10 grains (0.65 Gm.) of calcium carbonate intravenously; sodium salicylate and sodium bicarbonate orally, and 50 grains (3.25 Gm.) of sodium bromide every day for 3 days	Used successfully in a sporadic case with symptomatic recovery 3 days after onset
1943	Keschner [5]	Sedatives, extracts of endocrine glands, galvanic current and hydrotherapy advised	Temporary improvement; bromides and scopolamine advised against
1943	Piticariu, cited by Keschner [5].....	10 cc. of patient's cerebrospinal fluid given intravenously every week for 7 weeks	Good
1946	Walker, E. F., and Chaney, W. E.: J. Nerv. & Ment. Dis. **103**: 234-238, 1946	Galvanic stimulation of muscles and large doses of quinine sulfate	No change in symptoms

Friedreich's ataxia (hereditary sclerosis, spinal form) (Keschner [5]), the treatment is reported as best confined to the initial disease.

It is the purpose of this paper to present a case of paramyoclonus multiplex of Friedreich in a woman with a chronic psychosis, to comment on the differential diagnosis of the condition and to report the results of various stimulants and therapeutic procedures used.

PRESENTATION OF A CASE

History.—A white woman aged 46 was seen first at the Duke Hospital in September 1941, complaining of headaches and a draining left ear of thirteen years' duration. She had taken large quantities of bromide powders for relief

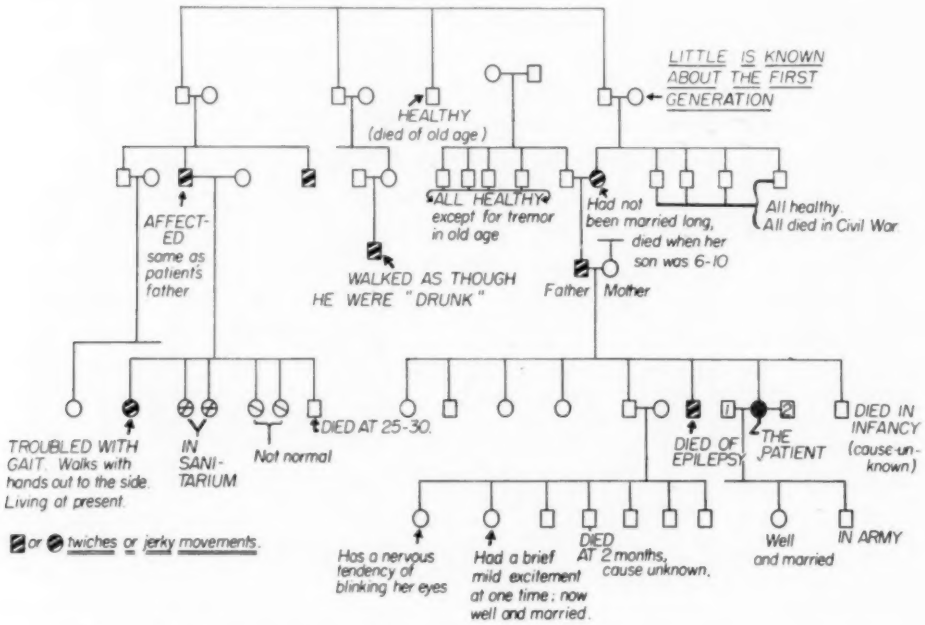

LITTLE IS KNOWN ABOUT THE FIRST GENERATION
HEALTHY (died of old age)
ALL HEALTHY except for tremor in old age
Had not been married long, died when her son was 6-10
All healthy All died in Civil War
AFFECTED same as patient's father
WALKED AS THOUGH HE WERE "DRUNK"
Father
Mother
TROUBLED WITH GAIT. Walks with hands out to the side. Living at present.
IN SANITARIUM
Not normal
DIED AT 25-30.
DIED OF EPILEPSY
THE PATIENT
DIED IN INFANCY (cause unknown)
or twiches or jerky movements.
Has a nervous tendency of blinking her eyes
Had a brief mild excitement at one time; now well and married.
DIED AT 2 months, cause unknown.
Well and married
IN ARMY

Fig. 1.—Chart illustrating the family history in the case reported. The presence of familial ataxias is suggested in the second generation. There was only 1 instance of idiopathic epilepsy in four generations. Although no relative was shown to have paramyoclonus multiplex, the family history indicates that many members of the family had regressive neurologic disorders.

of headaches, and when examined the blood bromide level was 77 mg. per hundred cubic centimeters. A diagnosis of bromidism with emotional upset, acetanilid poisoning, chronic otitis media and chronic mastoiditis on the left side, septal perforation and deficency anemia was made. Her hemoglobin concentration was 62 per cent of normal (15.5 Gm. represents 100 per cent). She was advised to return for further study, but she failed to do so.

The patient was not seen again until December 1942. She was referred with the diagnosis of Huntington's chorea. Her family history is shown in figure 1. Born of a normal, uncomplicated delivery, she had a healthy childhood but was always sensitive and was reared by a strict mother. She began school at the age of 6 years and completed five grades before she was forced to stop because

of sickness in the immediate family. She then worked until she was married, at the age of 16 years. She had two children. Her husband drank heavily, and she experienced epigastric pains and jerking sensations whenever he drank. Eventually she was told that she would die because of her nervousness if she did not leave her husband. After seven years of marriage, she separated from him and returned home to live. Here she regained her health and was well until five years later 1924, when she had a sudden pain in the left hypochondrium, after which a cholecystectomy, appendectomy, dilation and curettage were done. From that time she suffered from dysmenorrhea and had considerable menstrual irregularity. She began to take bromide powders. She was admitted to the North Carolina State Hospital at the age of 30 for nervousness, gastric trouble, trembling and vomiting. Here she remained thirty days. At the age of 32 she had a mastoidectomy on the left side. A persistent chronic drainage from the ear followed. At 32 she remarried, and her husband has now been in the Army for twenty-three years. According to the social service report, he was a good husband and did most of the housework. He gave his wife drugs to alleviate such symptoms as a feeling of nervousness, headaches, nausea, vomiting and sinus pains. At 37 she had a tonsillectomy, and at 39 she had an operation on the sinuses.

At 43 she began to have burning in her feet, which occasionally spread as high as the waist. In June 1941, at the age of 45, she became weak and was treated with injections of estrone, which improved her condition temporarily. In August 1941 she noticed numbness and a "funny feeling" in her feet, which increased and spread up her legs, producing a feeling "like icicles on the back of my legs." She was advised to discontinue the use of bromide powders, which she did.

In January 1942 her husband left with the Army, and she returned home to live with her parents. Here she had repeated head colds, a draining left ear, poor appetite, gastric pains, attacks of vomiting and vague pains in her back. She took many drugs but became progressively worse. In June 1942 she voluntarily requested admission to the North Carolina State Hospital, where she was treated for two months for drug addiction. Five days after discharge she reapplied for admission and was kept an additional thirty days. She again left the hospital and after eight days returned for the third time. She was kept until December 1942, when she was transferred to the Duke Hospital. She had made many charges against the hospital and finally added that she became so scared she thought they were going to kill her.

Examination.—Physical examination revealed tenderness over the frontal and maxillary sinuses; chronic otitis media on the left side; complete adentia; two abdominal operative scars; mild cervicitis; external hemorrhoids; thoracic scoliosis, with concavity to the left; paresthesia in the feet and the lower portions of the legs (in the form of numbness for the most part), and frequent spontaneous myoclonic movements of the small toes, especially the second, third and fourth. These movements were symmetric in the region of appearance on the two feet, but asynchronous twitches occurred on the two sides, with considerable irregularity in rate and some variation in excursion. The movements seldom involved the great toes. They were accompanied with pronounced tightening of the long extensor tendons of the affected toes and at times with more extensive waves of movement (myokymia) in the entire calf on either side, particularly on the left. The movements of the small toes could be suppressed at will, though only momentarily, and were virtually eliminated for a longer time by voluntary muscular action of the feet and toes, including constant voluntary pressure of the foot down or back against resistance. The movements were accentuated when the patient was

recumbent. The muscular tone was rather flaccid. The tendon jerks were strikingly exaggerated throughout, with the ankle jerks relatively less accentuated, though brisk. The abdominal reflexes were definitely present only in the upper quadrants. An inconstant response was obtained to stimulation with cotton on the backs of the feet and toes and to pinprick on the pad of the small toe of each foot; the vibratory sense was retained at the wrists and ankles and on the pads of the toes; passive movements were intact, but inconstant responses were obtained to movements made with the small toes. The skin of the body was pallid, with much darker skin on the lower portions of the legs; and a rather pronounced white dermatographia, both to blunt and to sharp strokes on the skin of the trunk and abdomen, was found. Tests of coordination did not suggest ataxia.

The twitches disappeared during sleep, and the electrical reactions were normal. Her hemoglobin concentration was 77 per cent (15.5 Gm. represents 100 per cent); the red blood cells numbered 4,210,000 and the white blood cells 6,600, with a

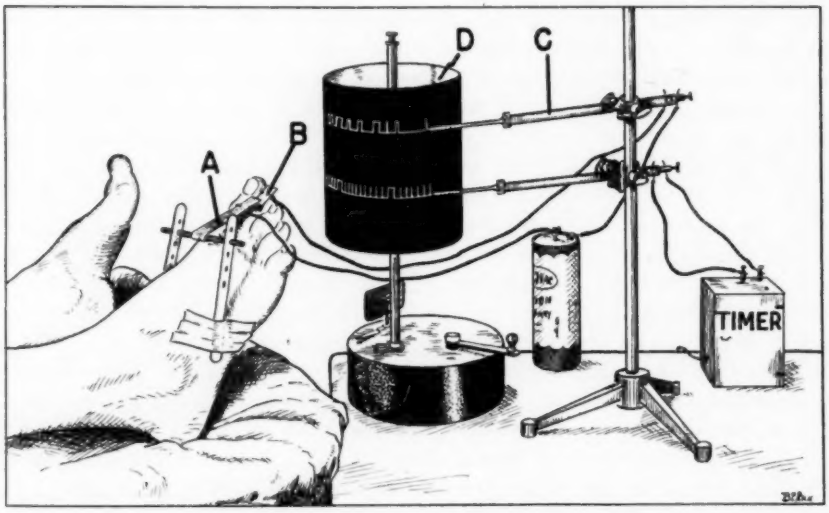


Fig. 2.—Apparatus used in recording the abrupt, bilaterally symmetric twitches affecting the distal muscles of the toes. Contact between points *A* and *B* complete an electrical circuit in series, with a recording electromagnetic timer (*C*). Each dorsal flexion of the toe allows the circuit to be completed, thus marking the contraction on the smoked drum (*D*).

normal differential formula. The Kahn and Kline reactions of the blood were negative. The Weltmann coagulation band was 7. The blood bromide level was normal; the dextrose tolerance test was normal, and serum calcium was 9.5 mg. per hundred cubic centimeters. The phosphorus measured. 3.5 mg., and the chlorides 546 mg., per hundred cubic centimeters; the sodium content was 142 milliequivalents, and the potassium 4.6 milliequivalents per liter. The chloride excretion tests gave normal results, and the gastrointestinal series was normal. The spinal fluid dynamics were normal; the protein of the fluid measured 54 mg., the sugar 68 mg. and the chlorides 702 mg., per one hundred cubic centimeters, with a negative Wassermann reaction, and normal colloidal gold and colloidal mastic curves.

Roentgenologic examination of the entire body revealed some fibrosis radiating from the left hilus of the lungs; a definite, but slight, prominence of the vascular markings in the middle meningeal region of the skull; midthoracic scoliosis, with

slight osseous reaction along the right margins, and a fractured ninth rib on the right side.

The electroencephalogram showed low amplitude waves from all regions of the head. Small, rounded, 20 per second waves were scattered throughout the tracings. The recording was not definitely abnormal.

With the Binet form L, the mental age was 14 years 2 months (chronologic age, 56 years), and the intelligence quotient, 94. She was particularly at ease with words but did not do so well in arithmetic reasoning or any other kind of problem situation.

During her six week stay in the Duke Hospital, she was cooperative but insisted on being given numerous medicaments, such as nose drops, ferrous sulfate, vitamins, sedatives, laxatives and "cough syrup." She was given intramuscular injections of liver extract every day, infra-red radiation to the sinuses and massage of the legs, and she had a hemorrhoidectomy. She was discharged in care of her daughter, it being against her will to leave the hospital.

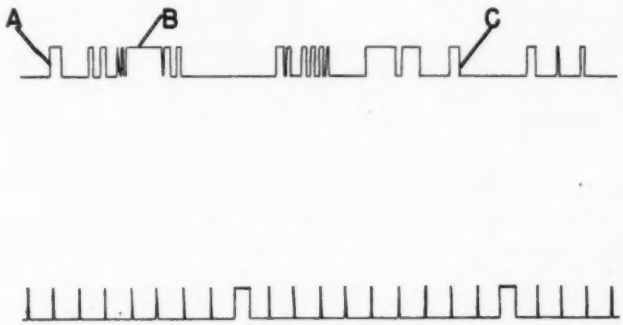


Fig. 3.—Kinetographic tracing (above) of movements of the toes while the patient was at rest. The upstroke (*A*) represents the dorsal flexion of the toes; the broad upper horizontal continuation of the upstroke (*B*), the sustained length of the contraction, and the downstroke (*C*), the release of dorsal contractibility. Below, the time is recorded in seconds.

KINETOGRAPHIC STUDY

Method.—The apparatus shown in figure 2 was used in all recordings. Records of three contractions occurring while the patient was at rest are shown in figure 3. Since the four smaller toes contracted at the same rate, it was necessary to record the movements of only one toe. The apparatus and toes were shielded from the patient's vision in all the recordings shown here.

Observations.—The observations recorded in this report (table 2) suggest that histamine iontophoresis applied over the motor points of the affected muscles and the avoidance of excitement are valuable adjuncts in the treatment of paramyoclonus multiplex. Histamine iontophoresis reduced the twitches from 51.2 to 13.3 per minute in ten minutes on one occasion and from 12.4 to 0.8 per minute in thirty minutes. After insult she cried, and the number of twitches increased from 30.6 to 54 per minute within ten minutes. It is interesting, in view of her psychic abnormalities, that repeated suggestion together with intramuscular injections of isotonic solution of sodium chloride did not change the rate of twitching. Nerve block with procaine offered cessation of twitching for two hours and fifteen minutes. Spinal anesthesia (100 mg of procaine hydrochloride) abolished the twitches bilaterally prior to motor weakness. Presence of the Babinski sign and intactness of

TABLE 2.—*Results of Various Stimuli Used in Study of a Psychotic Patient with Paramyoclonus Multiplex* *

Stimulant			Effect (Twitches per Min. for 10 Min.)		
Agent	How Used	Amount Used	Prior to Application of Stimulant	After Application of Stimulant	Comment
Neostigmine methylsulfate (1:2,000 solution = 0.5 mg.)	Intramuscularly (in right arm)	1 cc.	21.0	11.6	Patient remained cheerful throughout; talked of husband overseas
Histamine phosphate U. S. P. (1:1,000 solution in distilled water)	Iontophoresis over motor point of extensor digitorum communis longus of left leg	5 volts	1/11/43, 51.2	13.3	Patient cheerful; talked of nephew, of whom she held picture in hand
			1/20/43, 12.4	3.1 (at end of 30 min. only 0.8 per min.)	Brief pallor, followed by reddening and formation of temporary urticarial wheal
Sterile isotonic solution of sodium chloride	Intramuscularly (in right arm)	3 cc.	34.0	32.0	Patient cooperative throughout, talked of friends at home; solution used several times by injections in hip, with similar results
Procaine hydrochloride U. S. P.	Intramuscularly	3 cc. (1%)	32.0	20.6	No change in pulse, temperature or respiration
Amytal sodium	Intravenously	0.25 Gm. in 20 cc. isotonic saline solution	27.6	34.3	Respirations reduced by 2 per min.; no change in blood pressure or size of pupils; drug produced slight drowsiness, followed by light sleep in 1-2 hr., during which time twitches completely disappeared
Mecholyl	Iontophoresis	5 volts	21.1	23.1	Results obtained four days postoperatively, nausea; no increase in sweating or change in blood pressure; nausea relieved after stimulation begun
Procaine hydrochloride U. S. P. (nerve block)	Infiltration around common and superficial peroneal nerves	Sufficient to produce anesthesia but not to block movement	11.3	0.4	No twitches appeared after 10 min., until 30 min. later; patient cooperative but tired; return to normal control rate in 145 min.; no general effects from procaine
Pinching	Mechanically	5 min.	22.9	30.6	Patient reactive, complained, felt that no benefit would come from such irritation
Heat	Hot metal tubes applied over dorsal surface of skin	Touching intermittently for 5 min.	21.5	26.8	Patient complained of being afraid of burning blisters on feet; withdrew foot several times
Excitement	Scolded	5 min.	30.6	54.0	Tears came; patient turned head away; examiner left the room
Procaine spinal anesthesia	Subarachnoid injection into third lumbar space	100 mg.	41.4	18.1 (all twitches disappeared at end of 7 min. and remained absent thereafter for 50 min.	Preoperative dose of 1/150 grain (0.4 mg.) atropine; motor power never lost; anesthesia within 2 min.; hemorrhoidectomy begun 11 min. after anesthesia; Babinski sign present 1 min. prior to return of twitches; temperature sense returned 2 min. prior to return of twitches

* All results were obtained with the patient in the recumbent position. The recording apparatus was shielded from the patient's vision at all times.

the temperature sense prior to the return of twitches are interesting data for speculation concerning the origin of the twitches. Neostigmine methylsulfate used intramuscularly reduced the rate of twitching by one half. Sodium amytal and mecholyl iontophoresis offered no improvement in the number or the severity of the twitches.

COMMENT

The diagnosis of paramyoclonus was based on the occurrence of abrupt twitches in bilaterally symmetric muscle units, asynergic involvement and implication of distal muscle groups, all in the absence of other signs of involvement of the central nervous system. Many diagnoses were eliminated before the final diagnosis of paramyoclonus multiplex was reached. Syphilis was eliminated on the basis of the negative serologic reactions. Epilepsy was ruled out on the basis of the negative personal history, the lack of electrographic equivalents and the absence of epileptic stigmas. Although one brother had idiopathic epilepsy, the patient did not. Consequently, the diagnosis of Unverricht's [9] myoclonus epilepsy seemed unlikely. However, the familial disturbance of jerky movements and twitches is confusing (fig. 1). Poisoning from black widow spider bite could not be substantiated in the absence of boardlike abdominal rigidity, fever, leukocytosis or cyanosis. Trichinosis without facial edema, fever, involvement of the lids or eosinophilia, and in the presence of repeated negative examinations of the stools, was ruled out. The history and physical examinations did not suggest poisoning by arsenic or lead. Neuritis, as judged by tenderness of the nerve to pressure, was not encountered. Tetany seemed unlikely when calcium gluconate offered no relief. The Chvostek sign and carpopedal spasm were absent. Epidemic encephalitis deserves attention in view of the delusion and hallucinations; but in the absence of atrophy of the affected muscles, fever, leukocytosis, headache and facial, uvular and pharyngeal myoclonia it was ruled out. In hysteria muscular twitches conform to pattern movements, tend to be purposeful and probably would not eliminate the large toes, whereas the twitching in this case remained localized to the smaller four toes of each foot. Repeated psychic trauma was suffered; drug addiction (bromides) resulted, and the patient presented a maladjusted family history. Finally, after careful psychiatric studies by several examiners, it was concluded that the twitches were organic. Absence of rapid, violent, rhythmic movements; fever; muscular atrophy; occasional convulsions, and a fatal outcome would differentiate this condition from the electric chorea of Dubini. *Maladie des tics impulsif* is more widespread, involves the face and is characterized by definite movements. Careful analysis of the family history

9. Unverricht, H.: Die Myoklonie, Berlin, Franz Deuticke, 1891; Ueber familiäre Myoclonie, Deutsche Ztschr. f. Nervenh. **7**:32-67, 1895.

(fig. 1), absence of choreic movements and absence of progressive mental deterioration would seem to rule out a diagnosis of Huntington's chorea.

Galvanism, sedatives, chloral hydrate, hydrotherapy, rest and avoidance of excitement have been the most popular forms of treatment.

SUMMARY AND CONCLUSIONS

Mechanographic recordings of muscular twitchings and their change in rate after administration of various stimuli, summarized in table 2, were made in a case of paramyoclonus multiplex in which distal muscle groups showed abrupt twitches of bilaterally symmetric muscle units, with asynergic involvement. The literature abounds in methods of treatment, reflecting the obscurity of the disorder. The differential diagnosis of paramyoclonus multiplex involves the consideration of a rather large number of allied possibilities.

The results obtained with various stimuli suggest that, in addition to the general measures outlined in table 1 for the treatment of paramyoclonus multiplex, histamine iontophoresis may be helpful. They also emphasize the importance of avoiding excitement.

525 Physicians and Surgeons Building, Memphis 3, Tenn.

RETINAL PERIPHLEBITIS ASSOCIATED WITH PARAPLEGIA

B. P. SILFVERSKIÖLD, M.D.
STOCKHOLM, SWEDEN

RETINAL periphlebitis is a disease with recurrent hemorrhages into the vitreous and usually occurs in young men. The pathologic characteristic of the disease is a chronic inflammatory exudate within the walls of the vessels, being confined principally to the veins.

Retinal periphlebitis is believed to be due to an inflammation of infectious or toxic origin. It is not a clinical expression of a single disease. It has been found associated with cerebral vascular lesions. The most striking form is juvenile retinoangiopathy, or Eales's disease—recurrent intraocular hemorrhages in young adults. The etiologic factor has not been established; the cause may be a tuberculous, septic focus or thromboangiitis obliterans (Buerger's disease). The condition is found in young adults who have retinal and recurrent vitreal hemorrhages and thromboses, frequently leading to proliferating retinitis, detachment of the retina and glaucoma.

The 3 patients whose cases are reported here were under observation during 1943 and 1944 at the neurologic clinic of the Serafimer Hospital, Stockholm.

CASE 1.—S. Z., a workman aged 27 (1944).

Ocular Disease.—1939: There were retinal periphlebitis of the left eye and proliferating retinitis of the right eye.

March 28, 1939: Right Eye: Opacities were observed in the vitreous, some of them grayish white and others blood colored. Left Eye: No changes were noted.

Jan. 9, 1940: Examination of the right fundus showed large streaks with proliferating vessels.

February 13: Visual acuity was 1/60 in the right eye and 1.0 in the left eye. The right fundus showed white streaks, which were partly vascularized; the left fundus presented hemorrhages inferior to the disk; no hemorrhages were seen in the vitreous.

April 18, 1944: While lifting a heavy car, the patient felt a stab of pain between the shoulder blades, and simultaneously a dark streak appeared before the left eye. The diagnosis was retinal periphlebitis and hemorrhages in the vitreous of the left eye and complicated cataract of the right eye.

The right eye was amaurotic, with total cataract; the left eye had a visual acuity of 0.7; the vitreous was diffusely clouded. Downward, over a considerable area, were visible confluent retinal hemorrhages, with white streaks running along some of the veins. Centrally, only a small hemorrhage was present, just at the disk.

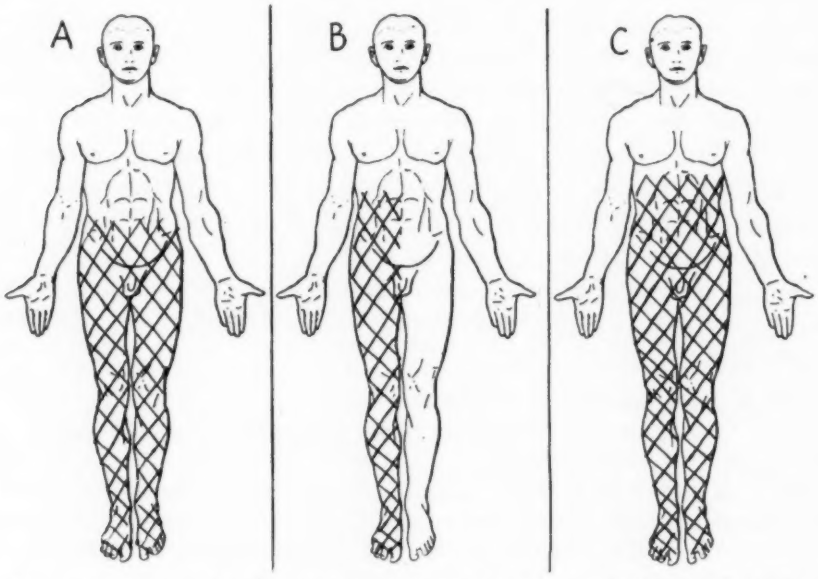
From the neurologic clinic, the Serafimer Hospital (Serafimerlasarettet).

May 2: Visual acuity was 0.9 in the left eye. The hemorrhage was resorbed for the most part.

Sept. 30, 1944: Large isolated opacities were noted in the left eye; some branches of the inferior temporal vein showed sheathing; no fresh changes were apparent.

Neurologic Disease.—May 1944: There was fairly rapidly progressing paraplegia, with incontinence of the urine and feces. After several weeks the legs were almost paralyzed, and the lower halves of the abdominal rectus muscles became paretic. The abdominal and cremasteric reflexes were absent. The muscle reflexes of the legs slowly became exaggerated. The plantar reflexes were of extensor type.

In the figure, *A* shows the area in which sensibility to temperature and pain was lost or reduced. Tactile sensibility and deep sensibility to movements in the toes were not affected to begin with but were later impaired.



Area of loss or reduction in temperature and pain sensibility (*A*) in case 1, (*B*) in case 2 and (*C*) in case 3.

June 1944: The first examination of the cerebrospinal fluid (lumbar puncture) showed 248 mononuclear cells, 10 polymorphonuclear leukocytes and 21 red cells per 3.2 cu. mm. The mastic curve was 000033. The Pandy reaction was positive. The Nonne-Apelt reaction was negative.

October 1944: On the patient's arrival at this hospital, the cell count was 59 mononuclear cells and 30 polymorphonuclear leukocytes. The total protein of the fluid was somewhat increased; the nitric acid test gave values of H 20 to 40, which correspond to 0.05 to 0.09 Gm. per hundred cubic centimeters.[1] The Wassermann

1. The total protein determinations were carried out with the nitric acid test (Bisgaard's method), which is widely used in Scandinavia. The corresponding absolute total protein values are given according to S. Izikowitz (Methodological and Clinical Studies on Total Protein, Globulin and Albumin Concentrates in the Lumbar Fluid, Stockholm, Karolinska Instituet, 1941).

and Müller conglobation (*Ballung*) reactions were negative. The guinea pig test was negative for tuberculosis. The Loewenstein culture was negative for tubercle bacilli.

Roentgenographic Examination.—The lungs and the spine appeared normal. Myelographic examination with oxygen (cisternal puncture) showed no changes (Lysholm).

Progress.—The general condition was good. The blood pressure was 125 systolic and 80 diastolic. There was no fever. The sedimentation rate was 16 mm. in one hour. The Mantoux test gave a positive reaction. The Wassermann and the Müller conglobation reaction of the blood were negative.

In November 1945 the legs were somewhat less paretic. The general condition was good.

CASE 2.[1a]—H. B., a porter aged 35 (1943).

Ocular Disease.—At the end of April 1943 some failure of vision was noted in the left eye. Visual acuity was 1.0 in the right eye and 0.7 in the left eye.

Left Eye: Many fine opacities were present in the vitreous; widespread periphlebitic changes with vascular sheaths and fresh hemorrhages were scattered through the fundus, but were most conspicuous temporally and downward.

July 24: Fresh hemorrhages were seen in the left eye.

September 9: Large central hemorrhages concealed the central part of the retina of the left eye and extended into the vitreous. Visual acuity was 2/50 in this eye. The right eye showed no changes.

October 6: Visual acuity in the left eye was limited to ability to count fingers at 30 cm. Small fresh hemorrhages and large organized hemorrhages were present in the central part of the eye.

The diagnosis was retinal periphlebitis of the left eye.

Neurologic Disease.—In June 1943 there was paresis of the bladder; in July 1943, fairly rapidly progressive (in two weeks) paralysis of the legs. The left leg was finally almost completely paralyzed; the strength of the right leg was somewhat less impaired. The abdominal and the cremasteric reflexes were absent but returned several months later. The muscle reflexes gradually became exaggerated. The plantar reflexes were of extensor type.

In the figure, *B* shows the area of loss of pain and temperature sensibility. Tactile sensibility and deep sensibility to movements in the toes were moderately impaired in both legs.

July 1944: The first examination of the cerebrospinal fluid (lumbar puncture) showed 156 mononuclear cells, 4 polymorphonuclear leukocytes and 128 red cells per 3.2 cu. mm. The Pandy test showed traces of globulin. The Nonne-Apelt reaction was negative. There was no definite excess of protein. (The nitric acid test gave values of 10-20, which correspond to 0.03 to 0.05 Gm. per hundred cubic centimeters). The mastic curve was 00010000. The Wassermann and the Müller conglobation reactions were negative. The guinea pig test twice gave a negative reaction for tuberculosis. The Loewenstein culture was negative for tubercle bacilli.

1a. The patient in this case was demonstrated by Dr. E. Franke at a meeting of the Swedish Neurological Association (Periphlebitis retinae och övergående fokal myelit med Brown-Séquard's syndrom och spinalt block i anslutning till B.C.G. vaccination, Nord. med tidskr. **23**:1496-1497, 1944).

Myelographic examination (Lindgren) with oxygen (by lumbar puncture only) revealed a tumor at the level of the fifth dorsal vertebra (?); somewhat later neurosurgical exploration (Norlén) showed no signs of tumor or arachnoiditis. Roentgenographic examination of the lungs and the spine revealed nothing abnormal.

Progress.—The general condition was good. The blood pressure was 160 systolic and 100 diastolic in June 1943 and 120 systolic and 90 diastolic in July 1943. There was no fever. The sedimentation rate was 4 mm. in one hour. The Wassermann, Kahn and Müller conglobation reactions of the blood were negative. Calmette (BCG) vaccination had been done six months before the illness. The Mantoux reaction was now positive.

From August 1943 there was slow improvement. The patient has been working since the autumn of 1944. He now walks with a stick (September 1945).

Case 3.—R. S., a salesman, aged 30 (1944).

Ocular Disease.—1932: There was retinal periphlebitis of the right eye.

1934: Retinal periphlebitis was present bilaterally. Visual acuity was 0.2 in the right eye and 1/60 in the left eye. In the left eye, large hemorrhages were present in the vitreous. In the fundus a large hemorrhage lay temporally and downward. In the right eye, abundant minute hemorrhages were present in the vitreous, with papillitis, fresh choroiditis inferior to the disk and perivascular changes in the peripheral parts. The patient was treated with injections of tuberculin. Later more hemorrhages appeared.

1935: At the last examination, visual acuity was 0.5/60 in the right eye and 1/60 in the left eye. Since 1936 no more ocular troubles have occurred.

1944: Visual acuity was 1.0 in the right eye and 0.6 in the left eye. The optic disk was somewhat red, with blurred edges and remnants of exudate on the right disk. Bilaterally white streaks extended into the vitreous.

Neurologic Disease.—May 1944: There was fairly rapidly progressive (in three days) paraplegia and paresis of the bladder. The right leg became paralytic; the left leg became somewhat stronger. The abdominal reflexes were lost. The muscle reflexes of the legs were weak to begin with; the plantar reflexes were extensor in type.

In the figure, *C* shows the area of loss of pain and temperature sensibility. Tactile sensibility was almost unimpaired. Deep sensibility to movements in the toes was lost on the right side and reduced on the left side.

May 1944: The first examination of the cerebrospinal fluid (lumbar puncture) revealed 50 mononuclear cells, 15 polymorphonuclear cells and 224 red cells per 3.2 cu. mm. The Pandy reaction for globulin was positive; the Nonne-Apelt reaction showed traces of globulin. The mastic curve was 00012210. The total protein was somewhat increased. (The nitric acid test gave values of 20 to 40, which correspond to 0.05 to 0.09 Gm. per hundred cubic centimeters.) The Wassermann and the Müller conglobation reactions were negative. The guinea pig test gave a negative reaction. The Loewenstein culture was negative for tubercle bacilli.

Myelographic examination with oxygen (cisternal puncture) revealed nothing abnormal (Lysholm). Roentgenographic examination of the spine showed a normal condition.

Progress.—The general condition was good. The blood pressure was 120 systolic and 80 diastolic in May 1944. There was no fever. The sedimentation

rate was 2 mm. in one hour. The Wassermann, Kahn and Müller conglobation reactions of the blood were negative.

Since July 1944 the patient has been gradually recovering. However, he is still using a wheel chair (September 1945).

In these 3 cases the following essential symptoms were present: (1) a characteristic retinal periphlebitis with recurrent hemorrhages into the vitreous followed by (2) paraplegia with paresis of the bladder and reduced sensibility mainly for pain and temperature (in 1 of the cases there was unilateral reduction only, the picture resembling a Brown-Séquard syndrome) and (3) pleocytosis.

Cases of retinal periphlebitis combined with neurologic disturbances have certainly been described in the literature. In these earlier cases, however, the neurologic symptoms, such as epileptic fits, diplopia and hemiplegia, were not characteristic.

Ballantyne[2] (1909) observed a picture resembling retinal periphlebitis in 2 patients with renal disease and epileptic fits; later (1937), with Michaelson,[3] he described a beautiful case of retinal periphlebitis in a patient with epilepsy of many years' duration and psychic disturbances. Loewenstein,[4] in 1931, reported a case of obvious retinal periphlebitis and, in 1934, a case of iridocyclitis, in both of which the ocular condition was combined with disseminated neurologic disturbances. He concluded that he had found cases with tuberculosis of the cerebral vessels. Ter Braak and van Herwaarden (1933)[5] reported cases of what they called ophthalmo-encephalomyelitis, in which the neurologic symptoms resembled disseminated sclerosis (with slight abnormality of the cerebrospinal fluid); the ocular symptom, however, were not characteristic in most of the cases. Marchesani and Stauder[6] (1935) reported cases in which retinal periphlebitis was more or less closely associated with such conditions as hemiplegia, diplopia and aphasia; the cerebrospinal fluid was not examined. The last-named authors expressed the belief that the morbid picture in their cases was due to thromboangiitis obliterans (Buerger). From some of these articles, one gets the impression that a combination of the ocular disease with neurologic symptoms is fairly common.

---

2. Ballantyne, A. J.: Transient Convulsions in Two Children with Unusual Changes in the Fundus Oculi, Ophthalmoscope **7**:662, 1909.

3. Ballantyne, A. J., and Michaelson, I. C.: Case of Perivasculitis Retinae Associated with Symptoms of Cerebral Disease, Brit. J. Ophth. **21**:22 (Jan.) 1937.

4. Loewenstein, A.: Ueber ein neues Krankheitshild: Lähmung jugendlicher Individuen als Folge von Blutung aus tuberkulösen Hirngefässen, Med. Klin. **27**:879-880 (June 12) 1931; Mitteilung über das Krankheitsbild: Rezidivierende Lähmungen als Folge von Blutung aus tuberkulöserkrankten Hirngefässen, ibid. **30**:868-870 (June 29) 1934.

5. ter Braak, J. G., and van Herwaarden, A.: Ophthalmo-Encephalo-Myelitis (Encephalomyelitis Disseminata [Multiple Sklerose] mit ungewöhnlichen Augenerscheinungen), Klin. Monatsbl. f. Augenh. **91**:316-343 (Sept.) 1933.

6. Marchesani, O., and Stauder, K. H.: Ueber cerebrale Symptome bei Periphlebitis retinae (Angiopathia retinae juvenilis), Arch. f. Augenh. **109**:281-303, 1935.

It seemed that in these cases the connection between the neurologic symptoms and the ocular disease had too readily been assumed, and for that reason I made an investigation of the incidence of the disease at this clinic.

Retinal periphlebitis is not a common disease. The patient is usually treated in the hospital; nevertheless, only 25 patients with the disease were cared for at the ophthalmologic clinic in Stockholm during the ten year period from 1930 to 1939. The total number of patients at the clinic during the same period was 9,023.

Retinal periphlebitis is rarely seen at the neurologic clinic. I reviewed all 5,500 cases for the ten year period from 1930 to 1939 and found only 1 case in which retinal periphlebitis (residual) could be suspected. The neurologic diagnosis in this case was "encephalopathia chronica; sclerosis disseminata?", and the case is thus another of the type described earlier in the literature.

In order to find out whether retinal periphlebitis is commonly complicated by neurologic disturbances, I also made a follow-up study of the 25 patients with ophthalmologic disorders, the period of observation extending over six to fifteen years. Answers were received from 22 of the patients; none of them had any neurologic disease.

Neurologic complications of retinal periphlebitis must therefore be rare, and earlier investigations are probably misleading on this point. The fact that isolated instances of retinal periphlebitis occur in the great and heterogenous group of cases of chronic encephalopathia and the like evidently does not justify the conclusion that a correlation exists. In the present cases, however, the rare ocular disease appeared as the precursor of an uncommon and characteristic neurologic disorder (the interval between the ocular and the neurologic disease being short, in 2 of the cases). When 3 cases have been found, it seems justifiable to speak of a syndrome.

With regard to the etiologic factors, 5 of these 22 patients had been treated at a sanatorium for tuberculosis of the lungs during the follow-up period, and 2 of them had died. This is of interest, many authors having stated that retinal periphlebitis is a form of tuberculosis. Other causes are possible, however, and the etiologic agent in the present cases must be regarded as unknown. One can, of course, make the guess of disseminated sclerosis, but there is nothing to prove the validity of such an assumption, which would involve the hazardous hypothesis that *sclerose en plaques* can exist as retinal periphlebitis in the anterior part of the eye. Moreover, paraplegia with dissociated sensory loss of this type is not common in cases of disseminated sclerosis.

SUMMARY

Three cases of a remarkable syndrome are described. The patients were all young men about 30 years of age. First they exhibited characteristic retinal periphlebitis with recurrent hemorrhages in the vitreous. After varying intervals of time, four to six weeks only in 2 cases, the ocular disease was followed by subacute paraplegia, with considerable pleocytosis.

During a follow-up period of one to two years the patients were observed to show improvement in varying degrees.

An investigation showed that a combination of retinal periphlebitis and neurologic disease is rare.

Serafimerlasarettet.

CONGENITAL FACIAL PARALYSIS

J. P. MURPHY, M.D.
AND
W. J. GERMAN, M.D.
NEW HAVEN, CONN.

FACIAL paralysis occurring in infancy and childhood may be acquired or congenital. If the former, it is thought to be due to obstetric trauma, is almost always unilateral and is not accompanied with paralysis of other cranial nerves.[1] Congenital facial paralysis, on the other hand, is usually bilateral. Paralysis of the abducens nerves is an almost invariably associated finding, and there are often other evidences of faulty development of the brain stem and cervicobrachial region.[2]

The occurrence of congenital facial palsy and its association with extraocular paralysis was first described by von Graefe, in 1880, and by Möbius, in 1888 and 1892.[2f,g] Since that time reports of over 60 cases have appeared in the literature and have been collected by Henderson.[2f] Of differential diagnostic interest, especially in the event of the rare unilateral case, is that the superior group of facial muscles is always more severely affected than the lower group.[2b,e] Many combinations of developmental defects accompanying facial diplegia and paralysis of the abducens nerve have been reported. These include paresis or paralysis of the oculomotor, motor trigeminal, glossopharyngeal and hypoglossal nerves, clubfoot and malformation of the upper extremity and chest. In 8 cases there was hypoplasia of one pectoral

From the New Haven Hospital.

1. Bonar, B. E., and Owens, R. W.: Bilateral Congenital Facial Paralysis, Am. J. Dis. Child. **38**:1256 (Dec.) 1929.

2. (*a*) Thomas, H. M.: Congenital Facial Paralysis, J. Nerv. & Ment. Dis. **25**:57, 1898. (*b*) Vogt, O.: Infantile Beweglichkeitsdefekte im Bereich der Hirnnerven, in Lewandowsky, M.: Handbuch der Neurologie, Berlin, Julius Springer, 1911. (*c*) Schmidt, A.: Angeborene multiple Hirnnervenlähmung mit Brustmuskeldefect, Deutsche Ztschr. f. Nervenh. **10**:400, 1897. (*d*) Fry, F. R., and Kasak, M.: Congenital Facial Paralysis, Arch. Neurol. & Psychiat. **2**:638 (Dec.) 1919. (*e*) Ullrich, O., in Bumke, O., and Foerster, O.: Handbuch der Neurologie, Berlin, Julius Springer, 1936, vol. 16. (*f*) Henderson, J. L.: The Congenital Facial Diplegia Syndrome: Clinical Features, Pathology, and Aetiology, Brain **62**:381-403, 1939. (*g*) Hicks, A. M.: Congenital Paralysis of Lateral Rotators of Eyes with Paralysis of Muscles of the Face, Arch. Ophth. **30**: 38-42 (July) 1943.

muscle group and mamma, while in 1 instance the musculature of the shoulder girdles was virtually absent.[2f]

Pathologic examination was made in 4 cases.[2f] In 2 cases there was gross evidence of hypoplasia of the pons and medulla oblongata, while in all cases the motor cranial nerve nuclei of this region were either absent or composed of pyknotic, hyperchromatic ganglion cells, reduced in number. Bonnevie,[3] from a study of a strain of mice (Bagg-

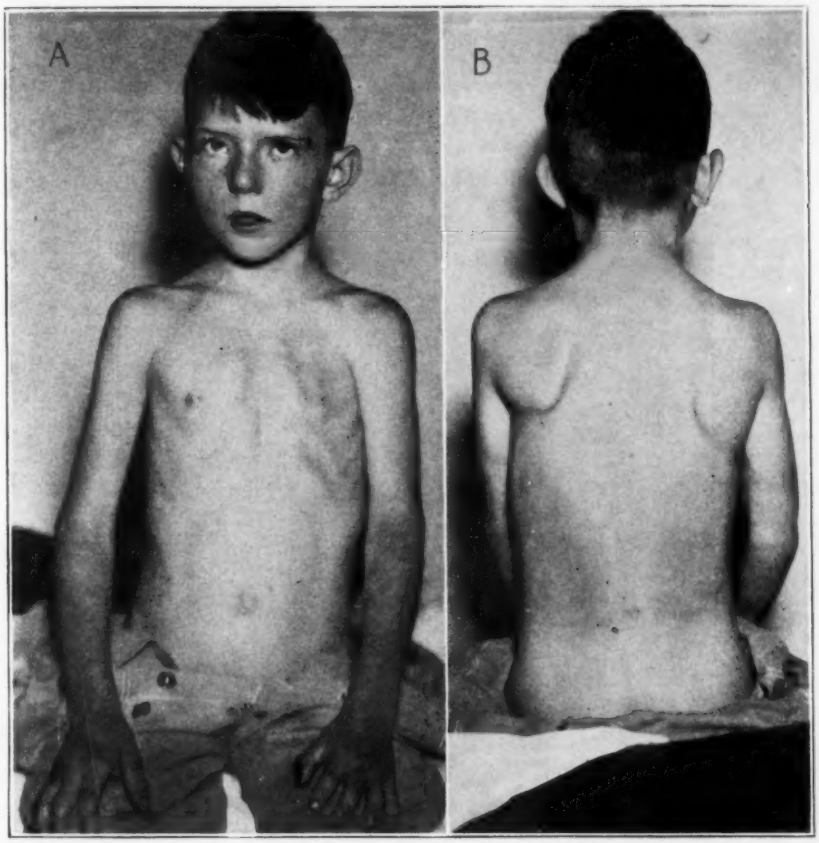


Fig. 1.—*A*, bilateral facial paralysis with associated developmental defects. Note the staring expression, open mouth, hypoplastic left nipple and pectoral muscles and malformed left hand. *B*, posterior view of the same patient, showing small left scapula and virtual absence of the latissimus dorsi muscle on that side.

Little) in which craniobrachial paralysis tends to develop during intrauterine life, suggested that malformation of the cerebrospinal fluid system is responsible for the development of this condition. There have been no other explanations of the etiologic factor.

3. Bonnevie, K.: Embryological Analysis of Gene Manifestation in Little and Bagg's Abnormal Mouse Tribe, J. Exper. Zool. **67**:443, 1934.

The following case is reported not only because of the manifold evidences of agenetic and dysplastic disease of the neuromuscular system but also because of encephalographic findings, thought to indicate hypoplasia of the metencephalon.

REPORT OF A CASE

D. P., a white boy of 8 years, was admitted to the neurosurgical service of the New Haven Hospital on July 19, 1940, because of facial paralysis and maldevelopment of the left hand.

The family history was free from stigmas of congenital defects. The patient was an only child. The mother's course of pregnancy was uncomplicated. The baby was born at full term, spontaneously. He presented an immediate feeding problem—"couldn't get any suction." When the infant was 2 months old, his

Fig. 2.—Encephalogram, right lateral erect projection, showing extreme dilatation of the basal cisterns, particularly the cisterna pontis, the cisterna interpeduncularis and the cisterna chiasmatis.

aunt noticed that he was unable to close the eyelids. It also became apparent that he was unable to look to either side. From early infancy asymmetry of the face was notable and the boy had difficulty in retaining food in his mouth. He drooled almost constantly. He was slow in talking, not being able to form words until the age of 2 years. At 5 years of age it became obvious that the left hand was smaller than the right. There was no evidence of mental defect.

Physical examination revealed a well nourished, friendly and cooperative boy. He had a peculiar unemotional, staring expression, the facies being virtually immobile. The skin of the left half of the face was rough and desquamating; that of the lower eyelids appeared atrophic, and the vibrissae were epilated. There was pronounced bilateral conjunctivitis.

Paralysis of both external rectus muscles was complete. At rest the left eye was rotated inward 15 degrees from the midline. The eyelids could not be closed farther than three-quarters the width of the palpebral fissures. The patient could

not wrinkle the forehead or elevate the eyebrows. The corners of the mouth drooped. The jaw deviated slightly to the left, but the masseters contracted strongly and equally. The gag reflex was sluggish, and the palate was elevated poorly. The mouth remained open, and the patient drooled (fig. 1 *A*).

The skin over the left breast was thin, and the nipple was almost absent. The pectorales, teres major and minor, serratus anterior and latissimus dorsi muscles of the left side of the chest and the left arm were hypoplastic and barely palpable. The left scapula was smaller than the right. The left hand was smaller than the right, and the index and fifth fingers were rather short (fig. 1 *B*).

Encephalographic examination disclosed enlargement of the basal cisterns, particularly the cisterna pontis, the cisterna interpeduncularis and the cisterna chiasmatis. The horizontal distance from the ventral margin of the pons to the floor of the fourth ventricle was decreased from the normal (Davidoff and Dyke [4]; fig. 2).

The rest of the usual laboratory examinations gave results within normal limits.

The multiplicity of physical defects suggests their common developmental nature, and the roentgenographic finding of dilatation of the basal cisterns indicates congenital defect. It is of interest that there was associated maldevelopment of the breast and the muscles of the left side of the chest, as in the cases reported by Schmidt [2c] and Fry and Kasak,[2d] among others.

SUMMARY

A case is reported of bilateral facial paralysis, bilateral paralysis of the external rectus, paresis of the muscles of the jaw and palate and defective formation of the musculature of the left side of the chest, the left breast and the left hand. Congenital malformation (nuclear aplasia) of the cranial nerve nuclei is thought to explain the physical defects of the face and eyes. Encephalographic examination disclosed dilatation of the basal cisterns and hypoplasia of the pons.

New Haven Hospital.

4. Davidoff, L. M., and Dyke, C. G.: The Normal Encephalogram, Philadelphia, Lea & Febiger, 1937.

COGWHEEL PHENOMENON OF THE EYES

Its Clinical Significance

NATHAN SAVITSKY, M.D.
NEW YORK
AND
N. W. WINKELMAN, M.D.
PHILADELPHIA

THE COGWHEEL phenomenon of the eyes merits further study because of its clinical significance. There is no article on this subject in English. The only comprehensive résumé is one in German by Cords,[1] published as "*Pathologie der Führungsbewegungen*" and consequently completely overlooked for a number of years. The cogwheel phenomenon of the eyes is not mentioned at all in most of the neuro-ophthalmologic texts, such as those of Wilbrand and Sänger,[2] Posey and Spiller,[3] Lapersonne and Cantonnet,[4] Rea [5] and Lyle.[6] Spiegel and Sommer [7] and Kyrieleis [8] mentioned it as occurring in postencephalitic paralysis agitans. Adrogué [9] (1942) referred to the work of Cords.

Javal [10] reported in 1879 that Lamare observed that ocular movements in reading are not smooth or gliding. They are interrupted by "saccadic"

Presented at the Seventy-First Annual Meeting of the American Neurological Association, San Francisco, June 28, 1946.

From the Department of Neurology, Columbia University; the Morrisania City Hospital; the Neuropsychiatric Division, Montefiore Hospital of Chronic Diseases; the Graduate School of Medicine of the University of Pennsylvania, and the Philadelphia Psychiatric Hospital.

1. Cords, R.: Zur Pathologie der Führungsbewegungen, Arch. f. Ophth. **123**:173, 1929.
2. Wilbrand, H., and Sänger, A.: Neurologie des Auges: Ein Handbuch für Nerven und Augenärzte, Wiesbaden, J. F. Bergmann, 1900-1917.
3. Posey, W. C., and Spiller, W. G.: Eye and Nervous System, New York, J. B. Lippincott Company, 1906.
4. Lapersonne, F., and Cantonnet, A.: Manuel de neurologie oculaire, ed. 2, Paris, Masson & Cie, 1925.
5. Rea, R. L.: Neuro-Ophthalmology, ed. 2, St. Louis, C. V. Mosby Company, 1941.
6. Lyle, D. J.: Neuro-Ophthalmology, Springfield, Ill., Charles C Thomas, Publisher, 1945.
7. Spiegel, E. A., and Sommer, I.: Neurology of the Eye, Ear, Nose and Throat, New York, Grune & Stratton, Inc., 1944.
8. Kyrieleis, W., in Schieck, F., and Brückner, A.: Kurzes Handbuch der Ophthalmologie, Berlin, Julius Springer, 1931, vol. 6, p. 724.
9. Adrogué, E.: Neurología ocular, Buenos Aires, El Ateneo, 1942.
10. Javal, E.: Essai sur la physiologie de la lecture, Ann. d'ocul. **82**:252, 1879.

movements (Duke-Elder [11]), the number of jerks remaining constant even though the distance of the text from the eyes varies. In 1891 Landolt [12] noted that the ocular movements were jerky in following a straight line and that the cogwheel phenomenon is more pronounced when the movements are slower. He suggested further study with the use of afterimages. Brown,[13] in 1895, noted little pauses and jerks of the eyeballs on following stationary structures. Dodge,[14] in 1903, stated that in normal persons continuous smooth movements of the eyeballs are seen only in what he chose to call pursuit movements. In 1912 Oehrwall [15] and Gertz [16] noted that the eyes follow moving objects smoothly. Kestenbaum [17] reported in 1921 that gliding or smooth movements of the eyeballs are absent in infants.

In this paper only cogwheel phenomena occurring during follow or pursuit movements are to be considered. Cogwheel movements of the eyes can best be described as repeated, very short pauses of the eyeballs followed by a rapid forward jerk. When a number of these pauses and jerks are present during a single excursion of the eye in one direction, it has to be differentiated from nystagmus. This differentiation is not difficult, because in nystagmus gross to and fro and pendular movements are usually evident. The actual pauses and jerks are not present. It is possible that what has been frequently reported as "nystagmoid jerks" (Zonta,[18] Spadavecchia [19] and Cushing [20]) was in reality this phenomenon.

The cogwheel phenomenon is considered abnormal when seen as the patient follows a smoothly moving object. The distance of the object

---

11. Duke-Elder, W. S.: Text-Book of Ophthalmology: The Development, Form and Function of the Visual Apparatus, St. Louis, C. V. Mosby Company, 1933, vol. 1, p. 619.

12. Landolt: Nouvelles recherches sur la physiologie des mouvements des yeux, Arch. d'opht. **11**:385, 1891.

13. Brown, A. C.: A Lecture on the Relation Between the Movements of the Eyes and the Movements of the Head, Nature, London **52**: 184, 1895.

14. Dodge, R.: Five Types of Eye Movements in the Horizontal Meridian Plane of the Field of Regard, Am. J. Physiol. **8**:307, 1903.

15. Oehrwall, H.: Die Bewegungen des Auges während der Fixierens: II., Skandinav. Arch. f. Physiol. **27**:304, 1912.

16. Gertz, H.: Ueber die kompensatorische Gegenwendung der Augen bei spontan bewegtem Kopfe, Ztschr. f. Psychol. u. Physiol. d. Sinnesorg. (Abt. 2) **47**:420, 1912-1913.

17. Kestenbaum, A., cited by Cords.[1]

18. Zonta, G.: I disturbi della motilità oculare nella encefalite epidemica cronica, Riv. sper. di freniat. **63**:374, 1939.

19. Spadavecchia, V.: Encefalite epidemica e manifestazioni oculari, Ann. di ottal. e clin. ocul. **62**:420, 1934.

20. Cushing, H.: Tumors of Nervus Acusticus, Philadelphia, W. B. Saunders Company, 1918, pp. 84-116.

from the eyes does not affect the intensity or frequency of the jerks. They are brought out more readily when the ocular movements are slow. They are most clearly seen in lateral movements, though they have been described in upward (Cords,[1] Gamper and Untersteiner [21]), and even rotary, movements of the eyeballs (Jensen [22]). The cogwheel phenomenon may be present only when the eyeballs are moved in one direction. Such unilaterality may have focal significance. We examined a patient with hemiplegia on the right side with definite cogwheel movements of the eyes only on following a moving object toward the hemiplegic side. This was present without paralysis of voluntary conjugate gaze or forced deviation of the eyes and without diplopia with the red glass test. Cords noted a definite positive correlation between the absence of opticokinetic nystagmus and the presence of the cogwheel phenomenon. Occasionally it may be present only during the first few movements of the eyeballs, disappearing as the eyeballs continue to move back and forth. Illumination, fatigue or mood of the patient was not found to be a significant factor in our own observations. C. Negro [23] reported the disappearance of the cogwheel phenomenon after instilling cocaine into the conjunctival sacs.

The cogwheel phenomenon is a disorder of pursuit movements. Command or voluntary movements of the eyes and pursuit movements differ physiologically. Bárány,[24] in 1907, observed that voluntary lateral movements of the eyeballs take place with less facility than when the eyes follow an object moving laterally. As far back as 1888 Wernicke [25] had discussed the difference between optic reflex movements and volitional movements of the eyes. Oppenheim,[26] in 1895, noted clearly a dissociation between command and follow or pursuit movements in 4 cases of pseudobulbar palsy. Roth [27] made similar observations in 1901 and used the term "ophthalmoplegia dissociata ideo-motor." We recently studied

21. Gamper and Untersteiner: Ueber eine komplex Gebaute postencephalitischen Hyperkinese und ihre möglichen Beziehungen zu dem oralen Einstellautomatismus des Säuglings, Arch. f. Psychiat. **71**:282, 1924.

22. Jensen, V. A.: Oculogyri instabilitet som initialsymptom ved dissemineret Sklerose, Nord. med. **21**:850, 1944.

23. Negro, C.: Di alcuni fenomeni oculari osservati im parkinsoniani encefalitici, Minerva med. **5**:12, 1925.

24. Bárány, R.: Die Untersuchungen der reflektorischen vestibulären und optischen Augenbewegungen und ihre Bedeutung für die topische Diagnostic der Augenmuskellähmungen, München. med. Wchnschr. **54**:1072, 1907.

25. Wernicke, C.: Herderkrankung des unteren Scheitelläppchens, Arch. f. Psychiat. **20**:243, 1888.

26. Oppenheim, H.: Kurze Mitteilung zur Symptomatologie der Pseudobulbarparalyse, Fortschr. d. Med. **13**:1, 1895.

27. Roth, W. C.: Demonstration von Kranken mit Ophthalmoplegie, Neurol. Centralbl. **20**:922, 1901.

a woman aged 54 with arterial hypertension who suddenly experienced dizziness and diplopia; the diplopia lasted only a short time. The neurologic examination showed a tegmental peduncular syndrome with ophthalmoplegia internuclearis anterior and a definite dissociation between pursuit and command movements of the eyes.

If the neural mechanism responsible for smooth pursuit movements is diseased or undeveloped, cogwheel phenomena of the eyes are seen. Hughlings Jackson,[28] in 1887, reported a case of dementia paralytica with "want of smoothness in the excursion of the globes." In 1894 he described the phenomenon as punctuation of motions of the eyeballs; he reported seeing it in hemiplegic persons. Abrahamson,[29] in 1921, noted the cogwheel phenomenon in cases of chronic encephalitis. Bing [30] described the same thing in 1923 and suggested the term "ocular cogwheel phenomenon." Velter,[31] Leroy,[32] Blum [33] and D'Arbela and Montanari [34] noted its occurrence in chronic encephalitis but did not report it in their own cases. Tchlenoff and Toulaeva,[35] Terrien [36] and Gamper and Untersteiner [21] each mentioned observing it in 1 case of chronic encephalitis. Fischer [37] saw this phenomenon in 12 of 20 cases; Young,[38] in 25 of 39 cases, and Critchley,[39] in 64 of 72 cases. Cords observed it in 21 cases of chronic encephalitis and commented on its importance in the differential diagnosis of this disease.

---

28. Jackson, J. H., in discussion on Gowers, W. R.: Conjugate Palsy of Ocular Muscles and Nystagmus, Lancet **1**:578, 1887.

29. Abrahamson, I.: Motor Disturbances in Lethargic Encephalitis, Arch. Neurol. & Psychiat. **5**:33 (Jan.) 1921.

30. Bing, R.: Das Zahnrahd-Phänomen und die antagonistiche Innervation, Schweiz. Arch. f. Neurol. u. Psychiat. **13**:77, 1923.

31. Velter, E.: Troubles oculomoteurs associés et régulation du tonus musculaire, Arch. d'opht. **40**:206, 1923.

32. Leroy, A.: Spasme du droit supérieur de l'oeil avec extension de la tête au cours d'un syndrome encéphalitique, J. de neurol. et psychiat. **24**:67, 1924.

33. Blum, J.: Contribution à l'étude du syndrome oculo-moteur tardif de l'encéphalite épidémique, Clin. opht. **32**:123, 1928.

34. d'Arbela, F., and Montanari, A.: La sintomatologia e le forme cliniche dell'encefalite epidemica, Riv. di clin. med. **29**:41, 1928.

35. Tchlenoff, L., and Toulaeva, N.: Syndrome post-encéphalitique infantile, Rev. neurol. **33** (pt. 1):563-576, 1926.

36. Terrien, F.: Les séquelles oculaires tardives de l'encéphalite épidémique, Progrès méd., 1935, p. 361.

37. Fischer, B.: Ueber vestibulare Beeinflussung der Augenmuskelstarre bei der Encephalitis epidemica, Deutsche Ztschr. f. Nervenh. **81**:164, 1924.

38. Young, A. W.: A Clinical Analysis of an Extrapyramidal Syndrome: Paralysis Agitans and Postencephalitic Parkinsonism, J. Neurol. & Psychopath. **8**:9, 1927.

39. Critchley, A. M.: The Ocular Manifestations Following Encephalitis Lethargica, Bristol Med.-Chir. J. **45**:113, 1928.

PRESENT STUDY

Our own observations on 641 patients have shown that this phenomenon may be present in a few conditions other than chronic encephalitis.

Conditions Investigated	Pursuit Movements	
	Present	Absent
Paralysis agitans—postencephalitic	69	4
Paralysis agitans—other types	15	10
Head trauma	19	21
Multiple sclerosis	24	19
Cerebral arteriosclerosis	13	20
Cerebral embolization	1	0
Epilepsy without diphenylhydantoin sodium	1	45
Epilepsy with diphenylhydantoin sodium	48	12
Narcolepsy	0	2
Ménière disease	0	20
Trigeminal neuralgia	0	1
Brain tumor	1	7
Disease of the spinal cord	0	10
Lesions of peripheral nerves and roots	0	18
Muscle and joint diseases	0	13
Functional mental diseases	1	93
Neuroses	3	151

We can confirm the great frequency of the cogwheel phenomenon with chronic encephalitis and found it an extremely important diagnostic aid in monosymptomatic and oligosymptomatic cases.

In a case in which an unusual speech defect (stuttering) began at the age of 16 the presence of a cogwheel phenomenon of the eyes focused our attention on the possibility of an encephalitic origin. The therapeutic test with atropine showed a diminution of the cogwheel phenomenon in this and in other cases. The stuttering also improved remarkably under treatment with atropine in the case cited.

Another illustrative case is that of a white woman aged 24, who was first seen in April 1941. There was no history even remotely suggestive of an acute attack of encephalitis. Oculogyric attacks began at the age of 18 and have occurred at irregular but frequent intervals since the onset. Examination showed no objective clinical evidence of chronic encephalitis except for a mild festination of speech. Her gait was normal. There was no increase of tone in any of the extremities. A cogwheel phenomenon in the eyes was noted at the time of the original examination. This further corroborated the diagnosis of chronic encephalitis.

Another case which illustrates the value of the cogwheel phenomenon is exemplified by a white youth aged 17 who was sent into the hospital with a diagnosis of schizophrenia. When first seen by us, he was in bed. The presence of a prominent cogwheel phenomenon in the eyes first directed attention to the true nature of his difficulty—a postencephalitic behavior problem. This was confirmed by the presence of defective decrease in swinging of the right upper limb while walking.

The cogwheel phenomenon of the eyes has been of especial importance to us in our cases of post-traumatic disorders. It is an additional objective sign which in a few unclear cases lends weight to the organicity of the syndrome.

A factory foreman aged 28 had been injured four years previously in a football accident. He was unconscious for five hours. The left ear drum membrane was punctured by the blow to his head. Dizziness with change of position and paroxysmal pains in the head had been present since the accident. He also reported experiencing frequent nausea on arising in the morning. He gave a history of

mild arterial hypertension for six months before the accident. His blood pressure was normal during each of three examinations. There were no positive neurologic signs except for a cogwheel phenomenon of the eyes with pursuit movements during each examination.

Another illustrative case is that of a dentist aged 44 who was seen early in June 1946. He had complained of headaches, dizziness, nervousness, forgetfulness and backache since an accident in September 1943. At this time, he struck his head when a mine blew up an ambulance in which he was riding. He sustained fractures of the left scapula and of the transverse processes of two lumbar vertebrae, a fracture and dislocation of the left clavicle and a severe injury to the right inner ear. There was a functional hemisensory syndrome on the left. The only positive neurologic sign was a cogwheel phenomenon of the eyes on looking to the left.

Another case of a post-traumatic syndrome was that of a man aged 40, who was seen in April 1945. Since an automobile collision on Feb. 13, 1945 he had complained of headaches, nervousness, dizziness with bending, and ready fatigue. He was unconscious for a few minutes after the accident, The neurologic examination revealed nothing abnormal. There was no evidence of psychogenic superimposition. A definite cogwheel phenomenon of the eyes was present.

The phenomenon has been observed in cases of multiple sclerosis.

In a woman aged 24 with mental symptoms resembling schizophrenia the presence of the cogwheel phenomenon suggested an organic neurologic disorder. As the condition progressed, the further signs and symptoms fitted into a symptom complex that was consistent with the diagnosis of multiple sclerosis. The patient died within the past year, and the gross and microscopic studies substantiated the diagnosis. Later in the illness the patient presented nystagmus in addition to the cogwheel phenomenon, and they were distinguishable from each other.

We have seen the cogwheel phenomenon in other cases of multiple sclerosis. In addition to Cords's observation in cases of disseminated sclerosis, Jensen,[22] more recently (1944), reported it in 10 per cent of a series of 50 cases. While not as valuable in the differential diagnosis of multiple sclerosis as in that of chronic encephalitis and post-traumatic syndromes, it can still prove useful in early and atypical cases of the disease. A search for this sign should, therefore, be included in the neurologic examination.

As far as we know this sign has not previously been noted in patients under diphenylhydantoin medication. Drug intoxication as a cause of the cogwheel phenomenon was noted only by Cords with phenobarbital poisoning. We have also observed it in cases of bromism. The cogwheel phenomenon has been most striking and most intense with diphenylhydantoin medication. In some cases it has been observed with other disturbances of the central nervous system, such as cerebellar dyssynergia. In a recent case studied by us, the patient had been given 6 grains (0.29 Gm.) of diphenylhydantoin sodium per day for four months. She began to show disturbances in gait and had difficulty in the proper coordination of movements of the hands. This patient showed both the cogwheel

phenomenon and nystagmus. In another patient, a white girl aged 19 years, the cogwheel phenomenon appeared even after one day's treatment with the drug. In no case which we have studied did we observe increasing tolerance to the drug with gradual decrease or lessening of the cogwheel phenomenon as time went on. We have gained the impression from this and from similar cases that when the cogwheel phenomenon occurs it bespeaks the onset of an encephalopathy from the diphenylhydantoin and that the drug should then be used with even greater caution. In practically none of our epileptic controls not taking diphenylhydantoin have we observed similar ocular signs.

We have also seen the cogwheel phenomenon of the eyes in a few cases of hyperthyroidism. Filippi-Gabardi [40] and F. Negro [41] also reported it in cases of exophthalmic goiter. Cords reported it in cases of cerebral tumor. We observed it only once with a brain tumor, atypical cases of chronic encephalitis and in cases of head injuries.

SUMMARY

1. The occurrence of the cogwheel phenomenon during pursuit movements of the eyes is abnormal.

2. Its presence indicates the existence of organic disease of the brain.

3. It has been seen most strikingly with chronic encephalitis and other organic diseases.

4. We have observed the cogwheel phenomenon of the eyes with diphenylhydantoin and bromide poisoning.

5. The phenomenon has proved of diagnostic value especially in atypical cases of chronic encephalitis and in cases of head injuries.

40. Filippi-Gabardi, E.: I disturbi della motilità oculare estrinseca negli ipertiroidei, Riv. oto-neuro-oftal. **17**:564, 1940.

41. Negro, F.: Le phénomène de la roue dentée dans les syndromes basedowiens, physiopathiques et vestibulaires, Rev. neurol. **1**:502, 1928.

LOCALIZED NONTRAUMATIC NEUROPATHY IN MILITARY PERSONNEL

EDWIN A. WEINSTEIN, M.D.
NEW YORK

WARS HAVE always stimulated interest in peripheral nerve lesions, and World War II has been no exception. During its course a number of cases of an unusual type of neuropathy were reported in Allied troops serving in England,[1] New Zealand and Egypt,[2] the Mediterranean area [3] and the South Pacific.[4] Although no common etiologic factor was demonstrated, the descriptions appeared to constitute a single clinical entity. The syndrome was characterized by a rapid, often painless, onset; a predominance of motor involvement, with frequently enduring paralysis and atrophy of the affected muscles, and a tendency to limitation to a single extremity, with a predilection for the shoulder girdle. When cases of this type were seen in World War I, they generally were ascribed to the pressure of the soldier's pack, so-called pack palsy. However, in the present series and in the cases described in other areas, this could have been a factor in only a small percentage, as most of the soldiers had duties which did not necessitate their carrying heavy burdens. Accordingly, some other etiologic factor was indicated. The present report deals with a review of the clinical characteristics of the 12 cases studied up to January 1944 in North Africa and 6 more cases seen subsequently in Italy and a consideration of the possible etiologic factors. Three sample case histories are presented.

REPORT OF CASES

CASE 1.—Pfc. R. S., a member of a field artillery battery, was admitted to a general hospital on Aug. 18, 1943. On July 25, while engaging in a boxing bout, he threw up his arm as a guard and felt the entire extremity go dead and numb.

1. Spillane, J. D.: Localized Neuritis of the Shoulder Girdle: Report of Forty-Six Cases in M. E. F., Lancet **2**:532-535 (Oct. 30) 1943.

2. Burnard, E. D., and Fox, T. G.: Multiple Neuritis of the Shoulder Girdle: Report of Nine Cases Ocurring in the Second New Zealand Expeditionary Force, New Zealand M. J. **41**:342-247 (Dec.) 1942.

3. Weinstein, E. A., and Gersten, D.: An Unusual Type of Peripheral Neuropathy: Report of Thirteen Cases, M. Bull. North African Theat. Op. (no. 5) **1**:9-11 (May) 1944.

4. Harvey, A. M.; Kuffler, S. W., and Tredway, J. B.: Peripheral Neuritis: Clinical and Physiological Observations on a Series of Twenty Cases, Bull. U. S. Army M. Dept., October 1944, no. 81, pp. 11-12.

The weakness had persisted, without pain at any time. Twelve weeks prior to the onset of illness he had an inoculation for typhoid.

Neurologic examination on his admission showed moderate atrophy of the deltoid, supraspinatus and infraspinatus muscles on the left side. There was complete paralysis of abduction of the left arm. The groove between the left scapula and the thoracic cage was deepened, and the left levator anguli scapulae muscle did not transmit an impulse on coughing, indicating a lesion of the dorsal scapular nerve. There were moderate atrophy and paresis of the biceps and triceps groups on the left and slight impairment of the extensors of the wrist and fingers and the intrinsic muscles of the hand. All the deep reflexes were intact, and there were no sensory changes. Examination of the spinal fluid revealed a clear, acellular fluid with a total protein content of 27.5 mg. per hundred cubic centimeters. Electrical examination showed reaction of degeneration in the left deltoid, supraspinatus and infraspinatus muscles. During a stay in the hospital of over four months, the patient made no improvement, marked atrophy developed and he had to be evacuated for further hospitalization.

The diagnosis was neuropathy involving predominantly the left axillary, dorsal scapular and musculocutaneous nerves.

Case 2.—Pvt. J. T. G., aged 19, a tank gunner, was admitted to a general hospital near Mateur, Tunisia, on Nov. 28, 1943. He had been well until November 7, when he awoke with paralysis and numbness of the entire left upper extremity. Power gradually returned to the fingers and at the wrist and elbow, but the patient was still unable to raise his left arm. Two weeks after the onset he had slight pain in the arm and shoulder, but this did not persist. He had not been in combat and had experienced no recent trauma. Twelve days before the occurrence of his paralysis he had received a stimulating dose of typhoid vaccine.

Physical examination on his admission showed moderate atrophy of the muscles of the left shoulder girdle and slight atrophy of the left arm and forearm. There was complete paralysis of abduction of the left arm, involving the deltoid, supraspinatus and infraspinatus muscles. On his coughing, no impulse could be felt in the latissimus dorsi and levator anguli scapulae muscles on the left. It was difficult to draw the left arm backward and outward, and the scapula was separated from the thoracic wall, indicating weakness of the rhomboid muscle. There was moderate weakness of the triceps, the extensors at the wrist and the extensors of the fingers supplied by the radial nerve. Tenderness to pressure in the left supraclavicular space was noted. Diminution of perception of pinprick, cotton wool and temperature was found over the dorsum of the left thumb and index finger and in a patch the size of a silver dollar on the lateral surface of the left arm in the distribution of the axillary nerve. The radial, ulnar and triceps reflexes were absent on the left side.

Examinations of the spinal fluid on two occasions showed no cells and a total protein content of 44.8 and 52.6 mg. per hundred cubic centimeters.[5] The patient showed no improvement. The musculature of the shoulder girdle became conspicuously atrophied without fibrillations. A compensatory scoliosis developed, with the convexity toward the affected side. After three months of illness he had not improved, in spite of physical therapy and administration of thiamine, and he was evacuated to the zone of the interior for further hospitalization.

The diagnosis was neuropathy involving the left axillary, radial, thoracodorsal and dorsal scapular nerves.

5. These are normal values for the technics employed.

CASE 3.—Pfc. P. S., a ward man in a hospital, was admitted to a general hospital on Oct. 8, 1943. On the morning of October 6 he had awakened with pain in the left shoulder. On the following day, while performing calisthenics, he noted that he was unable to raise his arms over his head. Nineteen days prior to the onset of his symptoms he had received an inoculation of typhus vaccine.

Physical examination showed winging of both scapulas and, in addition, paralysis of the left rhomboid and latissimus dorsi muscles. There were no sensory or reflex abnormalities. Examination of the spinal fluid revealed normal dynamics, no cells and a total protein content of 36 mg. per hundred cubic centimeters. Without any specific therapeutic measures, the patient improved and was discharged two weeks after admission, with slight residual winging of the left scapula. One month later there developed a schizophrenic reaction with paranoid delusions. The spinal fluid was again normal, and there was no change in the neurologic signs.

The diagnosis was neuropathy involving the left long thoracic nerve and the right long thoracic, thoracodorsal and dorsal scapular nerves.

CLINICAL FEATURES

The onset of symptoms was rapid in all cases, and disability came on at times with dramatic suddenness. The most common history was that the patient, on arising in the morning, was unable to raise his hand or arm. One soldier while boxing was startled to find that he was unable to elevate his guard. A nurse noticed weakness when she could not extend her hand to brush her hair. Pain was a less prominent feature than weakness. Although pain was present in some degree in 7 of the 18 cases, in only 2 instances, each of involvement of the axillary nerve, was it severe and persistent. A sensation of numbness or deadness was often perceived in the affected member. There were no symptoms of infection, such as sore throat, malaise, chills or fever, and no meningeal signs. In 1 case there had been a recent episode of malaria, but in the others there was no evidence of any systemic disease.

The upper extremities were affected in 16 cases, the paralysis being bilateral in 3. There was no predilection for either side of the body. The most severe damage was sustained by the nerves supplying the muscles of the shoulder girdle (14 cases). The radial nerve was involved in 4 instances, and the common peroneal nerve, in 2, each unilaterally. When the lesion was bilateral, the manifestations were asymmetric. When the disability was confined to a single upper extremity, there was involvement of multiple nerves in the majority of cases. In the 2 cases in which the signs were confined to a lower extremity there was paralysis of only the common peroneal nerve. The incidence of involvement of the nerves is shown in the following tabulation:

Long thoracic	6	Radial	4
Axillary	5	Musculocutaneous	2
Thoracodorsal	4	Ulnar	2
Dorsal scapular	4	Spinal accessory	2
Suprascapular	4	Common peroneal	2

The objective sensory loss was inconspicuous and was overshadowed by the degree of impairment of motor function. Sensory changes occurred mainly with lesions of the axillary and radial nerves and were limited to the isolated sensory supply of the nerve. In 1 case, for instance, a complete motor paralysis of the deltoid was accompanied with only slight hypalgesia. In another, with a complete wrist drop, sensory changes did not appear until several days after the onset of motor weakness. Although some patients complained of burning in the hypesthetic area, herpes did not develop. In the cases with signs referable to the brachial plexus, there was tenderness to pressure in that region. The fact that several of the nerves most commonly affected, the long thoracic, the thoracodorsal and the dorsal scapular, have no sensory cutaneous distribution accentuated the motor aspects of the syndrome.

The paralysis was maximal at the outset and was not progressive. The rate of improvement was extremely variable. Eight of the 18 patients regained power and were able to return to their duties within three to six weeks of the date of onset. In the others, however, a severe degree of paralysis persisted up to more than four months, and the affected muscles had gone on to considerable atrophy, without visible fibrillations. Electrical testing of 5 patients of this group revealed a lack of response to faradic stimulation with retention of galvanic excitability in the affected muscles.

Laboratory procedures showed nothing significant. The spinal fluid showed no increase in the cell count or the protein content. In several cases examinations of the spinal fluid were made at several stages of the illness, without significant change. Studies of the blood showed no leukocytosis or change in the sedimentation rate. Roentgenographic examinations of the spine and extremities also showed a normal condition.

COMMENT

Before it was recognized that these cases represented a clinical entity, there was considerable difficulty in diagnosis. Acute anterior poliomyelitis, a Guillain-Barré type of radiculoneuritis, pack paralysis, "Saturday night" palsy and hysteria were some of the initial impressions. Anterior poliomyelitis was easily eliminated by the absence of any febrile episode or meningeal signs and the presence of a normal, acellular spinal fluid. In the late stage, however, there is little to distinguish the residual paralysis and atrophy of the shoulder girdle from that resulting from poliomyelitis. The normal spinal fluid, likewise, served to exclude an atypical variety of the Guillain-Barré syndrome. A careful history for trauma was taken to rule out a condition analogous to the delayed paralysis that may follow injury to the ulnar nerve. Pack paralysis, the dysfunction of the musculature of the shoulder girdle, involving

chiefly the long thoracic nerve and attributed to the pressure of a heavy pack, was also considered. However, only 2 patients in the entire group had duties that necessitated their shouldering burdens, and neither of them had borne a heavy weight for some time. In the cases involving the radial nerve a "Saturday night" pressure palsy was excluded by the absence of a predisposing alcoholic episode, the long duration of disability with atrophy and the combination with lesions of other nerves. The 2 patients with palsies of the common peroneal nerve did not report a habit of sitting with their legs crossed. A search for so-called toxic factors, such as previous administration of sulfonamide derivatives, was fruitless. All patients had been on a standard Army diet, and there was no suggestion of avitaminosis. It soon became evident that the etiologic factor in the condition was not among the usual inflammatory, traumatic and toxic causes of peripheral nerve disease seen in civilian practice.

The pattern of a sudden onset, predominance of motor involvement with minor objective sensory changes, predilection for the shoulder girdle and tendency to implication of several nerves in a single extremity was striking. These features are identical with those of the peripheral neuropathy that occurs in rare instances after the injection of animal serum, the so-called serum neuritis. Cases have been described by many authors, with reviews by Allen,[6] Doyle [7] and Kraus and Chaney.[8] The onset of paralysis is typically a rapid one, coming on five days to two weeks after injection. Paralysis endures for from one to eighteen months, frequently with wasting of the affected muscles. Objective sensory changes are scant. The most common site of involvement is the nerves supplied by the fifth and sixth cervical segments. In Allen's analysis of 23 cases, involvement of multiple nerves in a single extremity was most common, with a lesser incidence of asymmetric bilaterality. A certain similarity is also present in the type of neuropathy that occurs with periarteritis nodosa. In the cases studied by Wechsler and Bender [9] the paralysis had a rapid onset, with single and asymmetric multiple nerve palsies, a distribution which the authors point out is rare in other conditions.

Because of this clinical similarity, some clue as to the etiology and pathogenesis in the present cases may be found in a consideration of the mechanism of nerve involvement in serum neuritis and periarteritis

6. Allen, I. M.: The Neurological Complications of Serum Treatment with Report of a Case, Lancet **2**:1128-1131 (Nov. 21) 1931.

7. Doyle, J. B.: Neurologic Complications of Serum Sickness, Am. J. M. Sc. **185**:484-492 (April) 1933.

8. Kraus, W. M., and Chaney, L. B.: Serum Disease of the Nervous System: Report of Three Cases, Arch. Neurol. & Psychiat. **37**:1035-1047 (May) 1937.

9. Wechsler, I. S., and Bender, M. B.: The Neurological Manifestations of Periarteritis Nodosa, J. Mt. Sinai Hosp. **8**:1071-1078 (Jan.-Feb.) 1942.

nodosa. The pathologic process in serum neuritis has been the subject of considerable discussion, but the most generally accepted view is that there is a primary disorder of the blood vessels supplying the nerve, with secondary parenchymatous change. It is also believed currently that the lesions of periarteritis nodosa occur on the basis of a hyperergic condition of the arterioles. Rich [10] found an acute arteritis presenting the same histologic picture in cases of both periarteritis nodosa and serum disease. Longcope [11] indicated that the neuritis which occurs in each condition is based on similar lesions in the vascular supply of the nerve trunks.

In none of the present cases had serum been administered in the three month period preceding the illness. Also, there was no evidence of generalized vascular disease. However, the sudden, at times apoplectiform, onset; the fact that the paralysis was initially maximal, and the localized nature of the paralysis suggested some sort of a vascular process. This impression was strengthened by the absence of any preceding trauma or evidence of inflammation. Reasoning by analogy with serum neuritis and periarteritis, one might postulate an anaphylactic or allergic factor. All the patients had received prophylactic injections of typhoid or typhus vaccine from one to twelve weeks prior to the onset of illness. It may be that this introduction of foreign protein is one etiologic factor in the production of increased sensitivity. The proof is not conclusive, as all military personnel are subjected to frequent immunologic procedures. However, in only a small proportion of persons who receive injections of serum do nerve lesions develop. It is also significant that cases of this type did not occur among civilians who did not receive prophylactic injections of vaccine in any quantity.

There have been a few adequately described instances of neural involvement of the type that we have described following administration of vaccine. Robinson [12] treated a patient who experienced foot drop four days after his second injection of typhoid-paratyphoid A and B vaccine. There was no pain and no sensory findings. The onset was rapid, with recovery in three and a half months. Hughes,[13] working with British troops, stated that he found it not uncommon to meet with cases of involvement of peripheral nerves three to four weeks after an

10. Rich, A. R.: The Role of Hypersensitivity in Periarteritis Nodosa as Indicated by Seven Cases Developing During Serum Sickness and Sulfonamide Therapy, Bull. Johns Hopkins Hosp. **71**:123-140 (Sept.) 1942.

11. Longcope, W. T.: Serum Sickness and Analogous Reactions from Certain Drugs, Particularly the Sulfonamides, Medicine **22**:251-286 (Sept.) 1943.

12. Robinson, L. J.: Neurologic Complications Following Administration of Vaccines and Serums: Report of Case of Peripheral Paralysis Following Injection of Typhoid Vaccine, New England J. Med. **216**:831-837 (May 13) 1937.

13. Hughes, R. R.: Neurologic Complications of Serum and Vaccine Therapy, Lancet **2**:464-467 (Oct. 7) 1944.

inoculation with tetanus toxoid or typhoid–paratyphoid A and B vaccine, but his case reports are largely those of patients who received both tetanus toxoid and vaccine. Peacher and Robertson [14] reported the case of a soldier in whom paralysis of the shoulder girdle developed seven days after an injection of typhoid–paratyphoid A and B vaccine. Pain was slight and transient. The deltoid supraspinatus, infraspinatus and biceps muscles were paralyzed and went on to atrophy. The only objective sensory finding was a slight hypesthesia in the distribution of the lateral cutaneous nerve of the forearm.

It is likely, then, that in the cases of peripheral neuropathy described the etiologic factor was not a traumatic or an infectious agent. Rather, the cause may have been a vascular sensitivity provoked by prophylactic injections of vaccine. The occurrence of nerve lesions after administration of serum is well established. It is possible that a neuropathy may develop after injection of a foreign protein, whether it be animal serum or dead bacteria.

It is questionable whether a pack palsy actually exists. The construction of an infantryman's pack makes it practically impossible for the normal brachial plexus to be compressed to the point of producing an enduring paralysis. Denny-Brown and Brenner [15] have demonstrated experimentally the degree of tourniquet pressure necessary to produce a lasting paralysis. This far exceeds the pressure that can be caused by a pack and rifle. Clinically, it is known that pressure palsies only rarely cause atrophy. Rather than to assume that the weight of a pack produces a nerve paralysis, it is more logical to believe that a soldier with an already weakened shoulder girdle will find it difficult and painful to bear weight. The comparatively painless onset of the lesion may leave the soldier with an unnoticed weakness of the serratus magnus or the rhomboid muscle for a time. The disability for ordinary duties will be slight. He will notice discomfort and incapacity and seek medical attention only when he is obliged to carry a large burden or perform heavy work. Woodhall,[16] for instance, cited a case in which there was a known history of weakness of the shoulder girdle and scapular winging. The patient presented the typical clinical picture of pack palsy and was considered to have had an accentuation and spread of his neural dysfunc-

---

14. Peacher, W. G., and Robertson, R. C. L.: Neurological Complications Following the Use of Typhoid Vaccine, J. Nerv. & Ment. Dis. **101**:515-526 (June) 1945.

15. Denny-Brown, D., and Brenner, C.: Paralysis of Nerve Induced by Direct Pressure and by Tourniquet, Arch. Neurol. & Psychiat. **51**:1-26 (Jan.) 1944; Lesion in Peripheral Nerve Resulting from Compression by Spring Clip, ibid. **52**:1-19 (July) 1944.

16. Woodhall, B.: Pack Palsy, Bull. U. S. Army M. Dept., December 1944, no. 83, pp. 112-117.

tion by the trauma of pack bearing. Thus, pack palsy may be the inability of a poorly innervated shoulder girdle musculature to bear weight.

SUMMARY

Eighteen cases of a type of localized peripheral neuropathy rarely encountered in civilian practice were observed among military personnel in the Mediterranean Theater.

The syndrome was characterized by rapid onset, predominance of motor involvement with scant sensory changes and frequently enduring paralysis and atrophy, with a predilection for the shoulder girdle. The most common pattern was the involvement of multiple nerves in a single extremity, with 3 instances of asymmetric bilaterality.

The etiologic factor is not known. However, close clinical similarity to the type of neuropathy that occasionally follows injection of serum and occurs with periarteritis nodosa is pointed out. It is suggested that the pathologic mechanism may be a similar type of hyperergic vascular reaction. In this case, previous administration of typhoid or typhus vaccine can be a sensitizing agent.

Pack paralysis, the dysfunction of the shoulder girdle musculature ascribed to the pressure of a soldier's pack, is discussed. It is felt that pack palsy does not exist as a primary entity and that in most of the cases so described the neuropathy is actually of the type presented here. The onset of symptoms and signs after carrying a pack is the manifestation of the inability of the previously weakened musculature of the shoulder girdle to bear weight rather than of a primary injury to normal nerves.

30 East Sixtieth Street.

News and Comment

NATIONAL ADVISORY MENTAL HEALTH COUNCIL GRANTS FOR TRAINING PROGRAMS

In accordance with recommendations made recently by the National Advisory Mental Health Council, the United States Public Health Service announces that three types of grants may soon be available under the National Mental Health Act. These grants would provide funds for training, for research and for community services.

The grants will be made to institutions offering training in psychiatry, clinical psychology, psychiatric social work and psychiatric nursing, for the purpose of improvement, expansion and inauguration of training programs in these fields. Application forms and complete information may be obtained from the Training and Standards Section, Mental Hygiene Division, United States Public Health Service, Washington 25, D. C.

The National Advisory Mental Health Council expects to take final action on these applications by the middle of April. Interested schools therefore are urged to make their applications.

The National Advisory Mental Health Council has authorized the United States Public Health Service to grant a total of not more than 600 stipends this year to graduate students in psychiatry, clinical psychology, psychiatric social work and psychiatric nursing. The Council has suggested that the stipends be equally divided among these four fields. The annual stipends range from $1,000 to $2,400 for clinical psychologists, psychiatric social workers and psychiatric nurses and up to $3,600 for psychiatrists, depending on the level of training for which the applicant is eligible. These awards will be made through the institutions collaborating in this phase of the training program of the United States Public Health Service. The names of these institutions will be announced on or about May 1. Interested applicants are requested not to write to training centers or to the United States Public Health Service about these stipends until the May announcement is made.

Grants for research relevant to the problems of mental health may be made on the recommendation of the National Advisory Mental Health Council to public and private institutions and to individuals. Application forms are obtainable now from the Research Grants Division, National Institute of Health, United States Public Health Service, Bethesda 14, Md.

To assist in development of adequate mental health programs at the community level, grants-in-aid will be made to states on a matching basis. These funds are handled by the mental health authority of each state. Professional and lay persons interested in specific service projects should bring their ideas to the attention of their state mental health authority.

Funds to inaugurate actual operation of the programs depend on Congressional appropriations. The earliest date on which such funds may be available is July 1, 1947.

RORSCHACH TEST SEMINAR

The Rorschach test seminar for 1947 at Michael Reese Hospital, Chicago, will be conducted on June 2 to 6, inclusive. Two groups of subjects will be

studied: (*a*) children presenting personality problems, and (*b*) adults with severe disturbances, including schizoid reaction patterns. Dr. S. J. Beck will demonstrate the test records and analyze them for the personality structures projected.

The course is open to persons with qualified background. For information write to Psychology Laboratory, Division of Neuropsychiatry, Michael Reese Hospital, Twenty-Ninth Street and Ellis Avenue, Chicago 16.

APPOINTMENT OF NATIONAL DIRECTOR, AMERICAN EPILEPSY LEAGUE, INC.

Mr. William H. Savin has been appointed national director of the American Epilepsy League, Inc. A Lt. Col., just released from the Army, Mr. Savin spent three years in Military Government in Italy. Prior to that he was executive director of the Family Service Association in Washington, D. C. Earlier he held an important post in the Philadelphia Community Fund.

The American Epilepsy League, Inc., which was established in 1939, is a national nonprofit organization stimulating interest in research and distributing information on epilepsy written in the light of present day knowledge and conditions.

Under the direction of Mr. Savin, state chapters of the Epilepsy League will be created as the expanded program permits, making it possible to bring more extensive health service and education to the 600,000 epileptic persons in this country.

Mr. Savin assumed his duties at league headquarters, 50 State Street, Boston, on February 15.

Correspondence

METHODS OF FREQUENCY ANALYSIS OF THE ELECTROENCEPHALOGRAM

To the Editor:—In a recent paper, Kaufman and Hoagland (Dominant Brain Wave Frequencies as Measures of Physicochemical Processes in Cerebral Cortex, ARCH. NEUROL. & PSYCHIAT. **56:** 207 [Aug.] 1946) have presented a critical appraisal of two methods of frequency analysis of the electroencephalogram, one devised by Brazier and Finesinger (Characteristics of the Normal Electroencephalogram: I. A Study of the Occipital Cortical Potentials in Five Hundred Normal Adults, *J. Clin. Investigation* **23:** 303, 1944), the other by my associates and me (Engel, G. L.; Romano, J.; Ferris, E. B.; Webb, J. P., and Stevens, C. D.: A Simple Method of Determining Frequency Spectrums in the Electroencephalogram, ARCH. NEUROL. & PSYCHIAT. **51:** 134 [Feb.] 1944). Our method is compared unfavorably with the Brazier method on the ground that it brings out only empiric changes and "masks the possibility of a rational interpretation of rates of events going on in the brain." By inference, the Brazier method is free of such objection. We feel that this criticism is based on a number of misconceptions and unduly detracts from the value of the method.

Contrary to the inferences of the authors, we have never claimed that our method is suitable for delineating "controlling kinetic events as rates within the cells." We do think, however, that it gives some information about the metabolic activities of the cells under certain conditions. Nor do we use the concept of dominant frequency in the manner that Kaufman and Hoagland ascribe to us. In earlier papers, my colleagues and I used "dominant frequency" merely to indicate the frequency or frequencies that made up 50 per cent or more of the record (Engel, Romano and others, 1944. Romano, J., and Engel, G. L.: Delirium: I. Electroencephalographic Data, ARCH. NEUROL. & PSYCHIAT. **51:** 356 [April] 1944. Engel, G. L., and Romano, J.: Delirium: II. Reversibility of the Electroencephalographic Data with Experimental Procedures, ibid. **51:** 378 [April] 1944). This was used chiefly as an aid in the tabulation of some of the data. Later we introduced the expression "mean frequency," which is the arithmetical mean of the distribution of countable waves per second interval (Engel, G. L.; Webb. J. P., and Ferris, E. B.: Quantitative Electroencephalographic Studies of Anoxia in Humans: Comparison with Acute Alcoholic Intoxication and Hypoglycemia, *J. Clin. Investigation* **24:**691, 1945). Obviously, such a mathematical expression can be derived only from countable waves, and low voltage fast activity cannot be included. In studying the effects of small changes in oxygen tension and blood sugar (Engel, Webb and Ferris, 1945) and the influence of certain drugs—alcohol (Engel, G. L., and Rosenbaum, M.: Delirium: III. Electroencephalographic Changes Associated with Acute Alcoholic Intoxication, ARCH. NEUROL. & PSYCHIAT. **53:** 44 [Jan.] 1945), quinacrine (atabrine) (Engel, G. L.; Romano, J., and Ferris, E. B.: The Effect of Quinacrine on the Central Nervous System, ARCH. NEUROL. & PSYCHIAT., to be published), melar-

sen (a pentavalent arsenical) (Engel, G. L.; Romano, J., and Goldman, L.: Delirium: IV. Quantitative Electroencephalographic Study of a Case of Acute Arsenical Encephalopathy, ARCH. NEUROL. & PSYCHIAT. **56:** 659 [Dec.] 1946) and Freon (a refrigerant, dichlorodifluoromethane) —on frequency, my colleagues and I intentionally selected subjects whose records showed 90 per cent or more of countable sine waves, and the mean frequency was calculated from the countable portions. Such a method of calculating mean frequencies actually corresponds closely to that used by Hoagland himself in his studies of critical thermal increments (Hoagland, H.: Pacemakers of Human Brain Waves in Normals and in General Paretics, *Am. J. Physiol.* **116:** 604, 1936). Kaufman and Hoagland refer to the alpha frequency as the dominant frequency and calculate a "mean alpha frequency" by "simply counting the number of alpha waves per second in records with dominant alpha activity for large samples and averaging, so that mean values statistically significant to 0.1 cycle per second were obtained." As long as the record remains regular and there is no disruption of synchrony, due to the experimental procedure or to artefact, all three methods (Hoagland, Brazier and Engel) should give comparable results. In the example presented by Kaufman and Hoagland, the mean frequency is 9.3 cycles per second; however, the spectrum presented would indicate that this was a somewhat irregular record or that the frequency count was inexpertly done.

Once synchrony begins to be disrupted, the calculation of a mean frequency or the designation of a dominant frequency becomes difficult or impossible and all methods break down. Hoagland (1936), in deriving the critical thermal increment for patients with dementia paralytica ("general paresis"), was thwarted by "irregular alpha waves" or by the disappearance of alpha waves, or he arbitrarily selected runs of regular activity for the calculation, a procedure open to criticism. As the frequencies become slower and the records more irregular, we present only the spectrum of frequency distribution and attempt to derive a mean frequency only from the countable activity, if there is sufficient countable activity to do so. By including a representative sample of the record, one can make a fairly complete characterization of the record.

This raises the fundamental question whether synchrony and frequency are always independent variables, as Kaufman and Hoagland would have one believe. In some circumstances, i. e., with the eyes open or during sleep, they probably are. But under the conditions in which we have used the frequency analysis method we think they are not wholly independent variables. Indeed, we have found that all noxious agents which derange cerebral metabolism not only alter frequency but eventually disrupt synchrony, producing varying degrees of irregularity (Engel, G. L.: The Clinical Applications of Electroencephalography, ARCH. NEUROL. & PSYCHIAT. **55:** 553 [May] 1946; abstracted, *Cincinnati J. Med.* **27:** 151, 1946). For this reason, the concept of a "dominant frequency" becomes less valid as the record becomes more abnormal; and mean frequency, if it can be calculated, while still empiric, probably gives a closer index of metabolic changes than does an arbitrarily selected dominant frequency. The example of opening the eyes, presented by Kaufman and Hoagland, is one obvious exception, and perhaps the Brazier method gives a more accurate picture of kinetics in such

circumstances. However, if the authors had utilized the record of sleep as an illustration, the Brazier method would also give an irrelevant result so far as the kinetics of the chemical reactions are concerned. Obviously, there are other variables that affect frequency and synchrony which may be more or less independent of cellular metabolism. These include the state of the cell membrane and of the surrounding fluid medium, the effects of influent impulses along nerve pathways (i. e., visual impulses), the still hypothetic pacemaker mechanism and the physical properties of oscillating systems and the recording devices (Engel, 1946. Dawson, C. D., and Walter, W. G.: The Scope and Limitation of Visual and Automatic analysis of the Electroencephalogram, *J. Neurol., Neurosurg. & Psychiat.* **7**:119, 1944).

Kaufman and Hoagland state that with our method a day to day variation was found in dominant frequency. We have already commented that their definition of "dominant frequency" as applied to our method is not used by us. Actually, calculations of mean frequencies in the records of 3 normal subjects repeated as many as thirty times over the course of five years showed maximum variations in the same subject of 0.5, 0.6 and 1.0 cycle per second, respectively, under comparable conditions. Obviously, "dominant frequency" as applied to our method by Kaufman and Hoagland and "mean frequency" as used by us are not the same.

The hypothetic example of a record produced by an electrical apparatus operating continuously at a rate of 10 per second and then intermittently at the same rate but turned off every five seconds, is not relevant because it is not correct. Analysis of the second record would yield a spectrum of 50 per cent 10 per second waves and 50 per cent uncountable (low voltage fast) waves. That is, half the one second intervals contain 10 waves and half contain no waves. The mean frequency of the countable waves would still be 10 per second. Obviously, the frequency is not 5 per second, as the authors state. Actually, the spectrum of 50 per cent 10 per second activity and 50 per cent uncountable activity characterizes exactly this hypothetic example, more completely indeed than either Brazier's or Hoagland's method.

We agree with Kaufman and Hoagland that it would be desirable to have a method of frequency analysis which would be useful as a measure of underlying chemical kinetics, but we do not believe this is possible of achievement except under certain limited conditions. It may be approximated in the analysis of records with a high per cent time alpha and in experiments in which the synchrony of the alpha activity is not significantly deranged. Under similar experimental conditions and with records having greater than 90 per cent time alpha, mean frequency as calculated by our method would seem to be essentially the same as the mean alpha activity calculated by Hoagland's method and would approach closely the figures obtained by Brazier. However, once the experimental procedure begins to disrupt synchrony, we believe that no method can yield an expression for frequency which is proportional in a quantitative sense to the changes in cellular respiration alone. In such circumstances, the Brazier method becomes relatively useless, whereas our method, even when a mean frequency cannot be calculated, yields a spectrum which gives at a glance an informative, if empiric, summary of the record. In our studies of delirium (Romano, J., and

Engel, G. L.: Delirium: I. Electroencephalographic Data, ARCH. NEUROL. & PSYCHIAT. **51**:356 [April] 1944. Engel, G. L., and Romano, J.: Delirium: II. Reversibility of the Electroencephalogram with Experimental Procedures, ibid. **51**: 378 [April] 1944), this method yielded meaningful characterizations of all records, whereas we found the method subsequently presented by Brazier (originally devised by Hallowell Davis) totally inadequate for many records.

In summary, then, we believe that the paper of Kaufman and Hoagland is based on an oversimplified concept of the electroencephalogram and that none of the methods they mention can reflect accurately the rates of changes of kinetic processes in the brain, except perhaps in the special circumstances which I have discussed. Our method, on the other hand, has a wide area of applicability as a means of summarizing empirically changes in the electroencephalogram, not only because it takes into account all the variables, but because it still yields an expression for mean frequency which is accurate and meaningful in the circumstances in which such an expression can be meaningful. Far from masking what goes on, our method gives a more complete characterization than any of the other methods discussed. It is also the simplest.

GEORGE L. ENGEL, M.D., Rochester, N. Y.
Strong Memorial Hospital.

Our criticism (Kaufman and Hoagland, 1946) of the Engel method of frequency analysis is based on the inclusion in the frequency measurement of the per cent time the frequencies are present in the record. Our criticism is not of Engel's use of his method, but of its extension as a general method of frequency analysis. An alpha frequency of exactly 10 cycles per second may be present from 5 to 100 per cent of the time from one subject to another, and the same 10 per second frequency may be present in the same subject under different conditions for much or for little time. Alpha frequency is essentially unchanged by opening and closing the eyes and by concentration of attention, though its per cent time present varies widely. Chemical agents may modify each of these variables independently or together, and an analytic tool is needed to separate these effects. The Brazier frequencies are independent of the per cent of time they are present, and the Engel frequencies, because of the nature of his method of averaging, must vary with the per cent time present.

Engel's "mean" frequencies, which are dominant frequencies on his plots, differ from Brazier's "dominant" frequencies by definition, and we do not wish to argue matters of definition. Our point has been to emphasize the existence of these differences and to indicate why their recognition is important in interpreting chemical phenomena in relation to the electroencephalogram. The Brazier dominant frequency is present and measurable in records obscured by both slower and faster waves than the dominant ones, and its changes are changes in true rates, which may be correlated with rates of physicochemical events in the brain.

Engel and his collaborators refer to "dominant" frequency, which in their earlier papers they appear to use interchangeably with their "mean" frequency; e. g., they state, "Our method gives a slightly false impression of the distribution of wavelengths greater or less than the dominant fre-

quency." This we found misleading, but the matter is now clarified by Engel's reply to our paper. Our evidence indicates that in any record as the per cent time alpha decreases from 100, as a limit, the error in frequency increases progressively and the "dominant" frequency, as determined by his method, itself decreases.

While Engel's method is convenient and has proved to be empirically useful in turning up interesting and important data, his mean frequency is not, in our opinion, as satisfactory a measure of rate as is Brazier's dominant frequency. Our data show marked variations with his frequency measure of per cent time alpha, as compared with the results obtained with Brazier's method. True frequency is a reciprocal time, and as such it is a pure measure of rate with the Brazier method and can be studied in persons with a low per cent alpha and with much low voltage fast activity. As Engel points out, the two methods give similar results for records containing high alpha activity. But per cent time alpha in the main certainly varies independently of frequency, and its inclusion in a measure of frequency is dimensionally unsound, and can be practically misleading if these limitations are not clearly borne in mind. This is especially likely to be so if the method should be used by future workers as a quantitative measure in correlating with specific chemical reaction rates.

We agree with Engel's criticism of our hypothetic model of a 10 cycle per second oscillator which is turned on and off every five seconds. If, however, the interval were 0.6 second on and 0.4 second off, this model would give a mean frequency of 6 per second with Engel's method and a dominant frequency of 10 per second with Brazier's method, since, as Engel and associates stated (ARCH. NEUROL. & PSYCHIAT. **51:** 134 [Feb.] 1944): "When a given interval contained both countable waves and low voltage fast activity, the type which occupied the greater portion of that interval was arbitrarily selected for purposes of designation." If one is interested in the physical system determining the rate of the 10 per second oscillator, a calculated mean rate of 6 per second would be misleading.

The physical sciences have advanced in proportion to the isolation of dimensionally meaningful variables and their apparently "oversimplified" study in functional relations. Brain waves are a manifestation of physiochemical events. As the field widens, it is certain that dimensional clarity, despite its limitations, will prove rewarding, as it has unfailingly been in other physicochemical problems.

HUDSON HOAGLAND, PH.D., SC.D., Shrewsbury, Mass.
222 Maple Avenue.

Abstracts from Current Literature

EDITED BY DR. BERNARD J. ALPERS

Physiology and Biochemistry

PHYSIOCHEMICAL MECHANISMS IN EXPERIMENTAL EPILEPSY. VICENTE H. CICARDO, J. Nerv. & Ment. Dis. **101**:527 (June) 1945.

Cicardo believes that the theories of cerebral hydration, vascular changes, humoral factors and local injury which have been advanced as explanations for the mechanism of the epileptic attack are inadequate. He suggests that, whatever the cause of the attack, cortical excitation appears to be determined by the release of potassium ions by the cortical neurons, which would lead, as in the case of nerve fibers, to depolarization of membranes, with consequent action currents, discharge of motor neurons and, finally convulsions. The author reviews the literature on the effect of the potassium ion on the nervous system. He has shown that during attacks of experimental epilepsy in the dog obtained by electrical stimulation of the brain or by the injection of convulsant drugs, such as metrazol, there is loss of potassium from the brain, as shown by analyses of blood plasma from the superior longitudinal thoracic vein before and immediately after the onset of convulsions. The loss of potassium is of cerebral, and not of muscular, origin, as shown in animals in which convulsions were suppressed by previous section of the medulla or by means of curarizing agents. Mobilization of potassium may be the origin of the action potentials recorded at the level of the cerebral cortex. Increase of cerebral activity accompanied with an increased loss of potassium would have, as a consequence, a parallel increase in the intensity and frequency of brain waves, which are propagated across the motor neurons, with the production of convulsive attacks.

CHODOFF, Langley Field, Va.

THE RELATION BETWEEN THE EFFECTS OF THE BLOOD SUGAR LEVELS AND HYPERVENTILATION ON THE ELECTROENCEPHALOGRAM. M. E. HEPPENSTALL, J. Neurol., Neurosurg. & Psychiat. **7**:112 (July-Oct.) 1944.

Since raising the blood sugar above fasting levels tends to prevent the appearance of delta waves on overbreathing, Heppenstall investigated this phenomenon in 71 cases of epilepsy, neurosis, psychopathic personality and post-traumatic states to see whether any group of subjects failed to react in this fashion. Two types of response were found: (1) a type in which raising the level of the blood sugar prevented the appearance of slow rhythms, the level at which stability in the electroencephalogram was achieved being low, probably 120 to 130 mg. per hundred cubic centimeters, and (2) a type in which slow rhythms still appeared, though diminished in number, and were elicited with blood sugar values above 130 mg. per hundred cubic centimeters. No correlation was found to exist between the age and the type of response. The more severe the degree of abnormality in the resting electroencephalogram, the greater was the probability that the response to elevation of the blood sugar would be unstable. Patients with neuroses were found exclusively to show the first type, and patients with epilepsy, the second type; the psychopathic personalities were equally divided on this basis, while, of the patients with post-traumatic states, those with mild head injuries usually showed responses of the first type. In the opinion of the author, the presence of this instability increases the probability that a patient is epileptic and the use of the test in cases of suspected epilepsy is recommended.

MALAMUD, San Francisco.

STUDIES ON AMEBOID MOTION AND SECRETION OF MOTOR END PLATES: V. EXPERIMENTAL PATHOLOGIC EFFECTS OF TRAUMATIC SHOCK ON MOTOR END PLATES IN SKELETAL MUSCLE. EBEN J. CAREY, LEO C. MASSOPUST, WALTER ZEIT, EUGENE HAUSHALTER and JOHN SCHMITZ, J. Neuropath. & Exper. Neurol, **4**:134 (April) 1945.

Carey and his co-workers report their observations on healthy, white rats (Mus norvegicus) which were subjected to trauma of the leg muscles. Pentobarbital sodium was used as the anesthetic, and the experiments were well controlled. Trauma was produced by striking the muscles of a limb with a wooden mallet. The number of blows varied from 50 to 150, with an approximate rate of 30 blows per minute. The striking force was 77 Gm., and the rounded striking face was 0.75 square inch (4.85 sq. cm.) in area. The estimated force was 150 Gm. per square inch (23 Gm. per square centimeter). In this way shock was produced with individual variation in response to a traumatic stimulus. The muscles were excised at different times after the trauma, but in all cases prior to cessation of cardiac and respiratory activities.

Teased muscle fibers prepared by a modified gold method were stained by different technics. Teased muscles previously subjected to gold impregnation gave the best morphologic evidence of secretory activity of the end plates. Over 1,800 gold preparations were studied as a basis for the investigation.

Carey and his co-workers report that the normal control motor end plates in the gastrocnemius muscle of the white rat under pentobarbital anesthesia were 40 to 60 microns in length. The retracted end plates had wide, short axonic terminals surrounded by a rim of the granules of Kühne 5 to 15 microns wide, whereas the expanded end plates had long, slender terminals with a diminished quantity or complete absence of these granules. There was a rhythmic quantitative change in the granules surrounding the normal motor end plates.

Thirty minutes after 50 mallet blows the traumatized gastrocnemius muscle had the majority of its end plates retracted into ball-shaped structures 15 to 60 microns in length, which were impregnated intensely with gold.

From thirty minutes to two hours after the blows ephemeral elongated streamers of Kühne's granules 3 to 500 microns in length appeared concomitantly with the progressive depletion of both the terminal axons of the end plate and the epilemmal axons external to the muscle fiber. These masses of granules were both internal and external to the muscle fiber in about 1 per cent of the motor trees; therefore large quantities of gold-impregnated muscle must be carefully teased in order to detect this evanescent stage in the morphologic depletion or loss of motor innervation of skeletal muscle in the early period following muscle trauma.

For thirty minutes to four hours after muscle trauma, some of the motor trees likewise were completely denuded of end plates, and others showed granular disintegration of the terminal axons of the end plates in various stages.

Concomitant with the substantial morphologic loss of the motor innervation of the gastrocnemius muscle, there was either weak or complete absence of response of the muscle to both direct and indirect electric stimulation through the sciatic nerve when the animal was in the terminal stages of profound shock, and before cessation of cardiac and respiratory activities.

The structural changes of the motor innervation were accompanied with morphologic changes in the skeletal muscle fibers characterized by irregular grouping of the cross striations comparable to certain Liesegang bands, by irregular granulation and by hyaline coagulation of the muscle protoplasm comparable to Zenker's so-called waxy degeneration of Zenker. The muscle nuclei were pyknotic. The morphologic changes were expressions of an underlying alteration in the chemistry of the neuromuscular apparatus and skeletal muscle fiber produced by traumatic shock. They were comparable to the alterations produced by the experimental injection of lactic acid into the zone of motor innervation of skeletal muscle.

The authors suggest that traumatic shock either augments the permeability of the end plates to the transmission of axonic material into the muscle or abnormally produces the delay in the dissolution of secreted nervous material in the muscles in certain places, or that both processes may be involved. This pathologic evidence supports the claim that the motor end plates are small glands of internal secretion. Traumatic shock augments their nervous secretion to the point of acute anatomic loss of certain motor innervations in some traumatized muscles and accompanying explosive degenerative changes of some of the muscle fibers. Excessive acidity due to anoxia may underlie these changes in nerve and muscle subjected to trauma.

GUTTMAN, Philadelphia.

SOME NEW DEVELOPMENTS IN THE MORPHOPHYSIOLOGY OF THE CEREBRAL CORTEX. S. SARKISOV, Brit. M. J. **2**:37 (July 14) 1945.

Sarkisov discusses some of the recent developments in the morphophysiology of the cerebral cortex. Pavlov's experiments on the conditioned reflex have led to further investigations on the part which the cortex plays in the most differentiated nervous activity and on the connection of the cortex with the functions of the internal organs. Recent electrophysiologic investigations include studies on the bioelectrical phenomena of the brain, on the finest structural features of the cerebral cortex, on the delicate mechanism involved in cerebral activity, on the electrophysiologic mechanism of the various sections of the central and peripheral nervous system in both the normal and the pathologic state, on the bioelectrical manifestations of the brain under different influences, on changes of the normal brain potentials in cases of mental disease and on bioelectrical manifestations of organic diseases of the brain.

Considerable knowledge has been acquired on the cortical formations and the various architectonic cellular structures of the most highly organized matter of the brain. The methods of architectonic investigation have been of great use in establishing the general features of the structure of the cerebral cortex, its division into separate areas and regions according to the character of the various cellular and fibroid laminas. These studies play a particular part in solving the problem of localization. There remains to ascertain how the formation of the neurons of the cortex in their entirety proceeds and to discover how in the process of development the connections between the various groups of neurons establish themselves inside the individual cortical formations, as well as between the various cortical regions.

ECHOLS, New Orleans.

THE EFFECTS OF HIGH ALTITUDE ON MAN. H. C. MATTHEWS, Brit. M. J. **2**:75 (July 21) 1945.

This is the first of two Oliver-Sharpey lectures delivered before the Royal College of Physicians of London, on the application of physiologic knowledge to the saving of life and to increasing the efficiency of flying personnel. The physiologic effects of high altitude are (1) the effects of lowered partial pressure of oxygen, which leads to incomplete saturation of the blood with oxygen and may indirectly disturb the carbon dioxide content of the blood, and (2) the effects of lowered atmospheric pressure, which may lead to bubble formation within blood vessels and tissues and to disturbances following expansion of the gas present in the viscera, sinuses and middle ear, and, after injuries to the chest of air within the pleura.

Three primary factors determine the intensity of symptoms due to lack of oxygen: the partial pressure of oxygen during exposure, the duration of exposure and the muscular activity of the subject. The effect of changing from oxygen to air at an altitude of 35,000 feet (10,500 meters) is unconsciousness in less than a minute, respiratory failure in seven to eight minutes and death in ten minutes. Lack of oxygen at an altitude of 5,000 to 10,000 feet (1,500 to 3,000 meters) produces reduced night vision at an altitude of 10,000 to 15,000 feet (3,000 to 4,500

meters), fatigue, headache, errors of judgment and indifferent mental condition; at an altitude of 15,000 to 22,000 feet (4,500 to 6,700 meters), reduced capacity for physical work, euphoria and loss of neuromuscular coordination, and at an altitude of 22,000 to 27,000 feet (6,700 to 8,000 meters), rapid loss of muscular control.

Bubble formation in the blood vessels and tissues at lowered pressure is produced by three main factors: the ratio of pressures and, to a lesser extent, the absolute magnitude of the change in pressure; the rate of change, and local conditions in the tissues. Decompression sickness above 30,000 feet (9,000 meters) is common and starts with pain in the muscles and joints and with pain in the chest, followed by sensory symptoms and anesthesia of the limbs, itching and tingling sensations. These are followed by collapse of central origin, during which the victim suddenly becomes intensely white, the pulse rate becomes slow and imperceptible and consciousness is lost.

With rapid change of pressure the pressure in the sinuses and the middle ear must equalize itself with that outside. If the eustachian tubes are patent, a fall of pressure of half an atmosphere in about half a second can be tolerated by the human subject without discomfort. However, with increasing pressure air must be admitted to the middle ear by opening the eustachian tube; this cannot be done rapidly enough to tolerate descent at anything like this rate.

ECHOLS, New Orleans.

Neuropathology

PARAMYOCLONUS MULTIPLEX. GEORGE B. HASSIN and RICHARD D. KEPNER, J. Neuropath. & Exper. Neurol. **4**:123 (April) 1945.

Hassin and Kepner report observations on a woman aged 51 who had paramyoclonus multiplex. For twenty-six years the patient had had paranoid schizophrenia and for ten years had had involuntary muscular contractions. These twitchings appeared to constitute a tic. Repeated examination revealed that the contractions affected different groups of muscles at various times, without regularity or sequence. The two sides, as a rule, failed to move together, and the face was not involved, though blinking of the eyes was observed frequently. The contractions were not rhythmic or regular in force or rate; they disappeared during sleep, lasted for weeks and months, and then disappeared, only to reappear after a lapse of time. During the patient's many years under observation at the hospital nothing was noted that would suggest any form of convulsive disorder.

Biopsy of muscle revealed changes in both the parenchyma and the middle layer of the mesoderm, the alterations being especially conspicuous in the latter. They consisted chiefly of hyperplasia of the mesodermal elements of the endomysium, perimysium and adventitial walls and were out of proportion to the parenchymatous changes of the muscle. Hassin and Kepner state that these changes are the result of muscular hyperactivity of many years' duration. They are a manifestation of the wear and tear of some muscle fibers due to overactivity, just as in epilepsy the changes in the brain are to be considered secondary to the convulsions. They conclude that the paramyoclonus multiplex of Friedreich is not an independent morbid entity but a form of incomplete epilepsy, or hysteria.

GUTTMAN, Philadelphia.

CEREBRAL FAT EMBOLISM AFTER ELECTRICAL CONVULSION THERAPY. A. MEYER and D. TEARE, Brit. M. J. **2**:42 (July 14) 1945.

Fatal accidents following electrical convulsion treatment are rare and are due, according to Alexander and Lowenbach, to three possible mechanisms: direct action of the electric current on the brain tissue through which it passes, resulting in vasoconstriction and blanching of the tissue; excessive stimulation of the vagovasomotor centers of the medulla, causing generalized circulatory disturbances, and impairment of the cardiac-circulatory-respiratory system of the patient to the extent of intolerance to the excessive demands imposed by a convulsion. Meyer

and Teare report the case of a man aged 53 in whom sudden death followed electrical convulsion therapy and was ascribed to cerebral fat embolism. They state that cerebral fat embolism has not yet been described after electrical convulsion treatment, although it has followed shock produced by azoman (triazol) and metrazol. None of the widely recognized causes of fat embolism, including fractures, severe contusion, deep laceration of the skin, severe burns, operations on adipose persons and forceful orthopedic manipulations could be demonstrated post mortem. Other possible causes, such as concussion, convulsions and the blood lipids, were considered, but the authors could not say which of these factors was operative in the case reported.

ECHOLS, New Orleans.

Psychiatry and Psychopathology

A NEW APPROACH TO THE PROBLEM OF HYSTERIA. FRANCIS POLLAK, J. Nerv. & Ment. Dis. **101**:268 (March) 1945.

Pollak believes that there is a cerebral basis for many hysterical phenomena and that a close parallelism can be drawn between clearly organic nervous symptoms and those which are usually considered to be purely psychogenic. Examples are given of visual, sensory and motor phenomena originally considered to be hysterical which later proved to be of organic origin. The author points out that the presence of purposiveness is not the exclusive possession of psychogenic phenomena, since purposiveness exists at all levels of development, from the most rudimentary and "physical" to the most complex and "psychic."

CHODOFF, Langley Field, Va.

DELAYED FAVORABLE EFFECTS IN PSYCHOTHERAPY. JOSEPH C. YASKIN, J. Nerv. & Ment. Dis. **101**:550 (June) 1945.

Yaskin discusses the conditions under which delayed benefit occurs from psychotherapy and the reasons for its occurrence.

The fundamental disturbance in the psychoneuroses is emotional, and in psychotherapy the attainment of insight by the patient remains largely an emotional process. The intellectual benefits of the so-called insight are probably of secondary importance. The emotional value of the transference relationship between the therapeutist and the patient is of special importance, and the former must frequently supply actual guidance and give meaning and direction to the experiences and reactions of the patients.

Delayed favorable effects of psychotherapy are observed principally in (1) patients who at the time of the treatment reject psychologic factors as causes of their illness; (2) patients who believe that psychologic causes are responsible for their disabilities but are unable to free themselves of the symptoms; (3) patients in whom external stress and strain cannot be eliminated or corrected at the time of the treatment; (4) patients in whom neurotic symptoms are associated with organic disease; (5) patients with certain constitutional psychopathic states.

The patient who at the beginning rejects psychologic factors as a cause of his disability, the patient with considerable external stress and strain and the the patient with existing organic disease may terminate the initial psychotherapy with dissatisfaction, and even resentment, but at a later date have a change of attitude conducive to more satisfactory rapport, perhaps in the hands of another psychotherapeutist. The initial therapy, though rejected, often leaves a definite therapeutic impression and acts as an "inoculation."

The patient who willingly accepts psychologic causes but fails to make satisfactory progress by reason of the inherent difficulties of emotional exploration and equilibration often discontinues the treatment but nonetheless has already procured some vague feelings and formulation regarding psychologic mechanisms and often unwittingly continues a self analysis, leading to a more satisfactory reevaluation and better adjustments.

CHODOFF, Langley Field, Va.

THE SIGNIFICANCE OF THE DEPTH OF THE PHYSIOLOGIC CUP OF THE OPTIC DISC FOR MENTAL ABILITY. MORTIMER OSTOW, J. Nerv. & Ment. Dis. **102**:571 (Dec.) 1945.

Since the optic nerve is derived from an outpouching of the brain it has been inferred that variations in the structure of the optic disk might be associated with variations in the physical structure of the brain. Ostow hypothesized that the depth of the physiologic cup of the optic disk might be associated with some aspect of mental function. In order to test the validity of this hypothesis, more than 325 patients at Saint Elizabeths Hospital and 155 patients from the Medical Center for Federal Prisoners were examined opthalmoscopically and the results compared with the diagnosis of the mental status and with various other factors. Psychometric data were available for 229 of the patients. By means of ophthalmoscopy, the degree of cupping if present was graded as marked, moderate or mild.

In the entire series of 480 patients examined, there appeared to be no relation between the mental diagnosis or a positive family history of mental disease and cupping of the disk. Among the psychotic patients, it was found that 61 per cent of those with mental ages of less than 14 years had flat disks, whereas this was true of only 36 per cent of those with mental ages of 16 years or over. On the other hand, only 17 per cent of the former showed deep cupping, whereas 43 per cent of the latter exhibited deep excavation. Among the nonpsychotic patients there was an even closer correlation between better intelligence and cupping of the disk and between a low intelligence quotient and flat disks.

A possible explanation of the findings would be that both the physiologic cup and intelligence are functions of the excellence of growth and maturation of the central nervous system.

CHODOFF, Langley Field, Va.

TICS AND IMPULSIONS IN CHILDREN: A STUDY OF MOTILITY. MARGARET SCHOENBERGER MAHLER, Psychoanalyt. Quart. **13**:430 (Oct.) 1944.

Mahler believes that there are three types of impulsions: (1) repetitive, strongly libidinized, simple or complicated motor actions which essentially serve the purpose of discharge, (2) actions which symbolize an aggressive gesture or magic defensive motor action of the ego against intolerable tension and conflict with the outside world and (3) stereotyped performances to obtain mastery of skill or learning or as a mechanism against interference. She considers that the second type constitutes a disturbance which is usually called a tic but which, however, she prefers to classify as "denial by magic repetitive gesture."

She classifies this type into three subtypes:

1. Tics resulting from a conflict between a vicariously used, and therefore overtaxed, affective motility and the claim for control. These tics, first manifested at a very early age in a conspicuous motor restlessness and hypermotility, are characterized by great interchangeability of the movements involved. They can be stopped voluntarily by the child for a period of time when outside pressures or the demands of the superego call for temporary control. The children are often characterized by an abundance of expressive motility. Later, usually at the age of 6 or 7, the impulsions and "tics" lose their volitional nature and their high reversibility potential through the catalyzing influence of the general powerful repression. This type of tic never seems to enter latency.

2. Tics which seem to develop after the child has entered school and has made a fair adjustment. There is always, however, a preschool history of fidgetiness and immaturity in the sense of playfulness. An increase of instinctual tension through trauma (automobile accident) or a sudden heightening of a sense of guilt (Holy Communion, threat of the consequences of masturbation) is followed by volitional, so-called nervous habits, such as blinking, picking the nose or rolling on the stomach. These habits, which are accompanied with an anxiety state, are usually opposed by threats of corporal punishment or of other consequences—a

pressure which facilitates the eruption of the impulse. The real tic, frequently coinciding with or followed by a general bodily jerkiness, appears a few weeks after the child has given up the autoerotic activities. Children with this form of tic are gravely inhibited in their voluntary expression, so that it is sometimes very difficult to get them to talk or to initiate activity. In them, defense and fear of being overpowered by the impulse are uppermost.

The differential diagnosis between tic and chorea is often very difficult. It sometimes happens that children known to have had multiple tics acquire rheumatic fever and chorea many years later. The author has seen at least 1 case in which a child with severe recurrent chorea and rheumatic endocarditis finally exhibited generalized incapacitating tics of a gestural and vocal quality.

3. Tics appearing in adolescents and in adults. These tics seem to have a more localized organ neurotic character and an obstinate local affinity to the eroticized organ, for which the involved muscle group in the tic is used as symbolization. Their psychodynamics is like that of traumatic neuroses. In all probability, they are those tics which Ferenczi described as single and living a so-called parasitic life. They are isolated from the ego function and are therefore very difficult to reach therapeutically.

All tiqueurs have definitely shown highly increased body narcissism, as well as a tendency to hypochondriacal self observation. In all three types of tiqueurs, overstimulation and fixation of component impulses have occurred, and the neuromuscular apparatus underwent vicarious or constitutional hypercatharsis in infancy and early childhood. In addition, infantilization and absolutely or relatively increased and inconsistent restraint of the affective motor component of the ego's kinetic function were noted in the anamnesis in cases of all three types, whereas simultaneously channeled performance motor function and compensatory ideational functions and skills were on the whole neglected. The kinetic function of the ego was especially damaged in those cases in which there was a lack of consistent and moderate general outside control to aid the development of the normal and balanced synthetic function of the ego. Owing to the erotization of the neuromuscular system in these cases, motility lags in development and is not well synthetized.

PEARSON, Philadelphia.

A REVIEW OF PSYCHOLOGICAL WORK AT THE BRAIN INJURIES UNIT, EDINBURGH, 1941-5. O. L. ZANGWILL, Brit. M. J. **2**:248 (Aug. 25) 1945.

Zangwill reports a review of psychologic work undertaken at the Brain Injuries Unit in Edinburgh during the last four years. This included studies and assessment of high grade intellectual defects, explorations of adjuvant technics in neuropsychiatric diagnosis and practical contributions to reeducation, disposal and resettlement. Some of his observations are enumerated. The author was particularly impressed with the prevalence of cognitive disabilities which have been ascribed to focal lesions. He was able to establish that focal disorders of visual perception, manual skill, language and calculation in their incipient or residual forms commonly take the shape of decrement of special abilities. He noted that some degree of memory or learning defect is extremely common in cases of cerebral lesions. He found that appropriate tests in delimiting the finer grades of organic intellectual impairment have been valuable in the differential diagnosis of organic and psychogenic sequels of head injuries; it was noted that the Rorschach method, in the majority of cases of post-traumatic injury, added little of real value to expert psychiatric assessment. The psychologist's contribution to reeducational procedures consisted in advice regarding these procedures for patients with psychologic handicaps, periodic psychometric assessment of progress made and preliminary exploration of technics which might govern reeducation of special disabilities. The results of psychologic examination were helpful in formulating a general course of rehabilitation and occupational therapy; on the other hand, the therapeutist's observations frequently indicated special disabilities displayed in a practical setting and suggested more intensive laboratory investigation. The psy-

chologist's findings were sometimes helpful in regard to problems of disposal and resettlement. The unit provided material for psychologic research on orientation in the confusional state, visual agnosia and disorientation associated with lesions of the nondominant hemisphere; clinical tests of memory impairment, and the Rorschach test in cases of acute head injury.

ECHOLS, New Orleans.

Meninges and Blood Vessels

SEQUELAE OF CEREBROSPINAL MENINGITIS. J. A. DEGEN and others, Brit. M. J. **2**:243 (Aug. 25) 1945.

Degen and his co-workers undertook a survey in an effort to determine whether there was an appreciable incidence of persistent symptoms following cerebrospinal meningitis and, if there was, to establish their nature and severity. Of the original 1,108 cases of meningitis, follow-up observations in 986 cases were sufficiently long to justify inclusion in the study. The conclusion was drawn that there is an appreciable incidence of persistent symptoms following cerebrospinal meningitis, the nature and severity of which have been defined but the discussion of which has been deliberately avoided.

ECHOLS, New Orleans.

MENINGITIS AFTER SPINAL ANALGESIA. MICHAEL KREMER, Brit. M. J. **2**:309 (Sept. 8) 1945.

Kremer reports 7 cases of infection of the subarachnoid space following spinal analgesia, 1 of which was fatal. In addition, he reports a case of meningitis following diagnostic lumbar puncture. The condition is characterized by a low grade infection, chronic in nature with a tendency to relapses; seldom is it immediately serious, because the infecting organisms are rarely of high pathogenicity. The condition has been considered to be (1) due entirely to the irritant action of the spinal analgesic, (2) secondary to infection elsewhere in the body or (3) subsequent to the introduction of infected material along the lumbar puncture needle. Kremer believes that infection due to faulty aseptic technic is the likeliest explanation. Treatment is chiefly prophylactic, but when the complication does occur the infection must be eliminated as soon as possible.

ECHOLS, New Orleans.

A CASE OF PARAPLEGIA AFTER CEREBROSPINAL MENINGITIS. H. HILTON STEWART, Brit. M. J. **2**:319 (Sept. 8) 1945.

Stewart reports an unusual case of a 12 year old girl in whom, one year after the acute phase of meningitis, there developed paraplegia which was due to organized adhesive meningitis producing diminution of the blood supply to the middorsal area. The adhesions were divided at operation, but for a year and a half the patient was unable to move her legs. After this time function gradually began to return, and three and a half years after operation there was no disability and examination revealed a completely normal person.

ECHOLS, New Orleans.

MENINGITIS DUE TO PENICILLIN—AND SULPHONAMIDE-SENSITIVE PITTMAN B STRAIN OF H. INFLUENZAE: RECOVERY. D. G. MCINTOSH and CONSTANCE F. DRYSDALE, Brit. M. J. **2**:796 (Dec. 8) 1945.

McIntosh and Drysdale report the case of a 2½ year old girl in whom meningitis due to Haemophilus influenzae developed during convalescence from meningococcic meningitis, which had been treated with penicillin and sulfadiazine. The patient responded to the administration of these drugs but had a relapse. Since the organism is insensitive to sulfapyridine, sulfamezathine (dimethyl derivative of sulfadiazine) was substituted, after which recovery occurred.

ECHOLS, New Orleans.

Diseases of the Brain

SYPHILITIC HEPATITIS AND GENERAL PARESIS [DEMENTIA PARALYTICA] OCCURRING SIMULTANEOUSLY. R. FINLEY GAYLE JR. and WALTER B. QUISENBERRY, J. Nerv. & Ment. Dis. **101**:220 (March) 1945.

Gayle and Quisenberry mention the infrequency with which syphilitic hepatitis and dementia paralytica are associated and report the case of a white man aged 38 in whom the two conditions were coexistent. The hepatitis was of the gummatous type and was associated with jaundice, splenomegaly and fever. The patient received malarial therapy for his neurosyphilis, and the curative effects of this treatment on the hepatitis resulted in a "therapeutic paradox," with consequent portal obstruction, ascites and death.

CHODOFF, Langley Field, Va.

DIFFERENT FORMS OF DIFFUSE SCLEROTIC PROCESS—PELIZAEUS-MERZBACHER DISEASE, STRÜMPELL'S FAMILIAL SPASTIC SPINAL PARALYSIS, LEUCODYSTROPHY —IN ONE FAMILY. MAX KASTAN, J. Nerv. & Ment. Dis. **101**:357 (April) 1945.

Kastan describes a family in which 4 members showed different forms of a diffuse sclerotic process. The presenting case, in which an erroneous diagnosis of multiple sclerosis had previously been made, showed the classic picture of Merzbacher-Pelizaeus disease (aplasia axialis extracorticolis congenita)—masklike face, spastic paralysis of the legs, exaggerated knee reflexes, horizontal nystagmus, ataxia, incoordination and intention tremor. A cousin of the patient, at the age of 25, displayed the characteristic features of spastic spinal paralysis of the familial type. A son of the first patient died at the age of 4, after a history of convulsions, progressive paralysis of the legs and inability to talk. Another son, when examined at the age of 4 years, was unable to walk or talk and showed the Babinski sign, hyperactive reflexes, conjugate deviation and constant seizures. The author suggests that familial spastic paralysis be classified as the spinal type of diffuse sclerosis.

CHODOFF, Langley Field, Va.

CIVILIAN ADVANCES AND INVESTIGATIONS IN NEUROSURGERY DURING THE WAR. COBB PILCHER, J. Nerv. & Ment. Dis. **101**:434 (May) 1945.

The problem of "closed" head injury, and particularly of concussion, has been elucidated by the work of Denny-Brown and Russell, which stresses the importance of acceleration of the head in the production of concussion-producing injuries. Walker, using a refined electroencephalographic technic, demonstrated a fleeting excitatory phase at the moment of impact producing concussion. This preceded the suppression of cortical activity, previously known to be characteristic of concussion. Clark and Ward showed that trauma to the head produced by a very rapid wave, of the type caused by "blast" in air or water, does not produce concussion and that this type of injury when applied to the trunk is not transmitted through vascular channels to produce injury to the central nervous system. Windle and his associates have demonstrated degenerative alterations in nerve cells of the cortex and brain stem in association with concussion. The ominous prognostic significance of respiratory disturbances, high temperature, pupillary abnormalities, severe paralysis and compound fractures has been emphasized by Pilcher and Angelucci.

Numerous studies have demonstrated that sulfonamide drugs when applied locally to the brain are safe, in moderate doses, except for sulfathiazole, which is definitely convulsogenic and should never be used.

"Fibrin foam" has been shown to constitute a new and valuable method of hemostasis in neurosurgery. A tough film also prepared from fibrinogen has been used for the repair of dural defects.

The problem of the "post-traumatic syndrome" has been studied from various points of view by Denny-Brown and his co-workers and by Ruesch and Bowman,

and both groups feel that most of the symptoms of this condition are of organic origin.

Cairns and Ascroft, reporting on the late results of wounds of World War I, found an appallingly high percentage of cases of traumatic epilepsy (34 per cent in Ascroft's series) following compound fractures and penetrating wounds.

Repair of defects of the skull with vitallium and tantalum has proved satisfactory in the hands of a number of workers.

It has been fairly generally agreed that operative decompression of a traumatized spinal cord is of value only if paralysis and anesthesia have been delayed or incomplete, if there is indication of continued compression or if a penetrating wound necessitates operation because of bacterial contamination, the presence of a foreign body or displaced fragments of bone.

The surgery of injured peripheral nerves has been advanced by the use of clotted plasma as a "nerve glue" and by the employment of the nonirritating and mallable tantalum as wires for nerve suture. There has been only slight success in the repair of long defects in nerves with autogenous or homogenous nerve grafts.

The electric skin resistance galvanometer of Richter has been an aid in the study of denervated areas.

CHODOFF, Langley Field, Va.

CHANGES IN PERSONALITY AFTER CEREBROSPINAL FEVER. M. NARASIMHA PAI, Brit. M. J. **1**:289 (March 3) 1945.

It has been noted that some adults who have apparently recovered from the acute stage of cerebrospinal meningitis may continue to complain of various symptoms, some of which are physiogenic and others psychogenic. Narasimha Pai made a study of 51 such patients and found that they showed a more or less definite syndrome, with individual variations. Definite neuropsychiatric changes appeared to progress until ten to fourteen months after the disease, when they remained more or less stationary. In most of the patients the disorder was predominantly psychogenic. Of 24 patients who were severely ill, 16 showed a syndrome suggestive of organic disease. It was noted that persons with no hereditary tendencies to neurotic breakdown may after an attack of cerebrospinal meningitis exhibit neuropsychiatric changes in personality.

ECHOLS, New Orleans.

TREATMENT OF EPILEPSY BY ELECTRICALLY INDUCED CONVULSIONS. G. CAPLAN, Brit. M. J. **1**:511 (April 14) 1945.

Caplan presents a preliminary report of the results of an investigation in which an attempt was made to replace epileptic fits, which may occur anywhere at any time, with convulsions electrically induced under controlled conditions of time and place. The convulsions were induced before breakfast once or twice a week by use of a simplified light weight machine designed by the author. Of 15 epileptic men treated in this way, 11 showed a pronounced reduction in the frequency of grand mal attacks; the other 4 showed no great change. Some improvement in the length and intensity of the postepileptic confusion was also noted. Fourteen of the patients had an associated psychosis, in half of whom this condition was considerably ameliorated. No serious complications occurred.

Caplan presents this report in the hope that it will stimulate further investigation of the method. The selection of the type of case and the duration of the beneficial effect of the treatment have still to be determined. However, the author believes that his results are encouraging enough to warrant further study of the method. The treatment is intended as an adjunct in cases in which fits occur despite a full dose of the anticonvulsant drug.

ECHOLS, New Orleans.

ARSENICAL ENCEPHALOPATHY. G. A. RANSOME, J. C. S. PATERSON and L. M. GUPTA, Brit. M. J. **1**:659 (May 12) 1945.

Ransome, Paterson and Gupta briefly review the etiology, symptomatology, diagnosis and treatment of arsenical encephalopathy, with special emphasis on the

value of postural treatment. According to Kinnier Wilson, the condition is fatal in about 75 per cent of cases. The authors describe 5 cases in which recovery followed postural treatment; they attribute survival of their patients to nursing in the sitting position. They summarize their management of such cases as follows: (1) examination of the patient; (2) lumbar puncture; (3) keeping the patient up on a back rest; (4) treatment of complications, such as pulmonary edema, fits and hyperpyrexia; (5) adequate antimalaria therapy; (6) administration of calcium or sodium thiosulfate intravenously, 0.5 Gm., with calcium gluconate and ascorbic acid if available (of doubtful value); (7) adequate hydration and nutrition, with a transnasal intragastric Ryle tube left in situ.

ECHOLS, New Orleans.

Diseases of the Spinal Cord

TWO CASES OF MORVAN'S SYNDROME OF UNCERTAIN CAUSE. HARRY PARKS and O. S. STAPLES, Arch. Int. Med. **75**:75 (Feb.) 1945.

Parks and Staples report their observations on 2 youngsters who had painless infections and ulcerations of the limbs. In each instance the common neurologic abnormalities consisted of a symmetric peripheral type of hypesthesia involving all four extremities, more pronounced distally than centrally. This was accompanied with trophic changes. Neurologic examinations otherwise revealed nothing significant except that the deep reflexes were either diminished or absent. Roentgenograms revealed as an early lesion loss of tufting of the terminal phalanges in the hands and feet. There was a varying degree of muscular weakness without apparent muscular atrophy. Biopsies of the skin revealed nothing remarkable, and in 1 case examination of a peripheral nerve showed nothing abnormal. There was no evidence of tuberculosis or leprosy.

The authors reviewed all the available reports of Morvan's syndrome in children; 7 cases in all have been described, and they did not present the clinical picture usually associated with syringomyelia.

There is no known cause for this peculiar neurotropic disorder, which occurs in children and runs a chronic course. It may resemble certain forms of syringomyelia but lacks the characteristic segmental distribution of sensory symptoms with disassociated sensory changes ordinarily found in this disease. It lacks also amyotrophy, spasticity and other signs indicating involvement of the upper motor neurons or of the spinal tract. It is not leprosy. It is a rare disease which warrants further study.

GUTTMAN, Philadelphia.

MASSIVE EXTRUSION OF LUMBAR INTERVERTEBRAL DISK. A. VERBRUGGHEN, Surg., Gynec. & Obst. **81**:269 (Sept.) 1945.

Verbrugghen thinks that insufficient stress has been placed on the serious complications which may occur when the ruptured intervertebral disk is inadequately treated. The extrusion of a large part of a disk may so compress the cauda equina as to cause weakness of one leg with disturbance of urinary function, or even a transverse lesion of the cauda equina with paraplegia and incontinence of the bladder and rectum. Most of the patients with lesions of the cauda equina seen by the author languished for days, weeks or months without a correct diagnosis being made. In all cases the lesion was at the lower lumbar level. The history was characteristically of cogwheel type, with gradually progressive spurts of trouble and the signs were those of acute compression of the cauda equina. The symptom complex varied from slight weakness of the legs below the knee with saddle hypesthesia to severe disturbance of sphincter control. Of 9 patients seen, 8 were operated on, and 1 died before anything could be done. Their cases represent the serious complications seen in 300 consecutive cases of typical herniated nucleus pulposus. In all but 1 of the 9 cases there was a history of backache for years, and in all but 2, a history of both backache and sciatica for

years. A history of trauma was obtained in 3 cases. The bladder mechanism was seriously involved in all but 1 case. Weakness and hypesthesia were observed in varying degrees. The Lasègue sign was positive in all the cases in which it was tested. The deep reflexes in the ankle were affected in all cases. The spine was tender on deep pressure in 6 of 8 cases. The intervertebral space was narrowed at the site of the herniation of the involved disk in 5 of 9 cases. Early diagnosis and operation are essential, but recovery may be slow and incomplete, even if the diagnosis is made early.

J. A. M. A.

SIXTH NERVE PARALYSIS AFTER SPINAL ANALGESIA. W. A. FAIRCLOUGH, Brit. M. J. **2**:801 (Dec. 8) 1945.

During a period of two years at the Auckland Hospital New Zealand, paralysis of the sixth nerve following spinal analgesia occurred once in 202 cases. The 10 cases in the series are briefly described. Theories of a mechanical, toxic and inflammatory origin have been suggested to explain the cause of paralysis of the abducens nerve following spinal injection. Fairclough submits some points concerning binocular vision and the necessary faculties concerned in its maintenance that seem to be definite contributing factors in causing the abducens nerve to be so often the earliest cranial nerve to supply clinical evidence of cerebral disease. Relief of the associated headache can be obtained by the inhalation of oxygen and keeping the head in a horizontal position. Covering the deviating eye gives relief for the diplopia.

ECHOLS, New Orleans.

Vegetative and Endocrine Systems

PITUITARY ADENOMA ASSOCIATED WITH CHRONIC DUODENAL ULCER. JOSEPH E. PISETSKY, J. Nerv. & Ment. Dis. **102**:537 (Dec.) 1945.

Pisetsky reviews the literature on the association of tumors of the pituitary gland and duodenal ulcer and reports an additional case. The patient had had frontal headache and failing vision associated with bilateral atrophy of the optic nerve for about fifteen years when he began to complain also of abdominal pain. Roentgenologic study in 1936 revealed evidence of both a tumor of the pituitary gland and a nonobstructive duodenal ulcer. In 1937 the patient was given a course of radium cannon treatment directed to the pituitary region. The condition remained stationary until 1941, when abdominal symptoms again appeared, and in 1942 roentgenographic examination revealed an old duodenal ulcer.

The large tumor of the pituitary had undoubtedly exerted pressure on the basal parts of the brain, especially the hypothalamus. There probably was also compression of the cerebral cortex, due to increased intracranial pressure. Thus, by alterations in formation and transmission of impulses to the visceral organs, the cerebral cortex and the hypothalamus could provide the neurologic substrate for the production of a duodenal ulcer. The immediate ulcerogenic process in the stomach may be a combination of increased peristalsis and vasoconstrictor action, resulting in areas of local ischemia, which are then acted on by gastric and duodenal hypersecretion.

CHODOFF, Langley Field, Va.

Book Reviews

Human Genetics. By Reginald Ruggles Gates, Ph.D. Two volumes. Price, $15. Pp. xvi + 1,518. New York: The Macmillan Company, 1946.

This large work is published in two attractive volumes, which have consecutive pagination. Three chapters of the first volume present a general view of the principles of the science of genetics, and groups of characteristics and abnormalities are discussed in the remaining chapters. Chapters covering neurologic, psychiatric and psychologic conditions appear consecutively in the second volume.

The chapters on general principles, in volume I, may be used as a review of the principles of genetics if their rather great limitations are kept in mind. There is failure to take account of the possibility of transmission of characteristics through substances in the cytoplasm. The revolutionary work of H. J. Müller and others on the environmental influences on mutation rates is not mentioned. The presentation of the concept of penetrance is distorted. This concept will be familiar to few medical readers. The term is used to describe the fact that certain characteristics which are transmitted by genes are found in otherwise similar pedigrees with different frequencies. Thus, blood types, being uninfluenced by any known environmental factor, show 100 per cent penetrance. Rickets, if it is related to a single gene, shows considerably less than 100 per cent penetrance, and shows zero penetrance if the level of vitamin D intake is high enough. Gates explicitly attributes to each gene a specific percentage of penetrance. This obscures the variability of penetrance under different conditions of life and, simultaneously, makes possible the assumption that any disease which tends to have some familial distribution is related to a gene of low penetrance.

The remainder of the two volumes is made up almost entirely of brief summaries of research papers, arranged according to diseases and conditions. Consequently, the work is somewhat like a vast review of the literature. When used as such it will be of some value to persons interested in the field. However, it does not pretend to be a complete review and cannot be considered a critical one. In most cases the author attempts no considered evaluation of the miscellaneous material he presents under a given heading. When he does introduce analysis other than that which comes from the specified sources, he frequently draws conclusions not warranted by the material presented. He consistently sees genetic relations as playing a much greater role than a truly biologic approach would have revealed. The level of reliability is low, although many valuable references are cited. The chapters on "Hereditary Variations," "Defects and Diseases of the Nervous System," "The Inheritance of Mental Defects" and "The Inheritance of Normal Mental Differences" take no account of the evaluation made in 1935 by the Amercian Neurological Association's Committee for the Investigation of Sterilization. These chapters exhibit clearly the result of the bias disclosed by the author on page 43 of volume I: "Those who . . . try to make out that all mankind are a single house-party, lacking only a common feeling of fellowship, do an injustice to science, truth and eugenics, which has never contemplated universal mixture of races as a desirable future for mankind." It is to be expected that this book will be cited frequently by eugenicists and by those who attribute social problems to genetic differences between men. It will be used with the greatest caution by scientists.